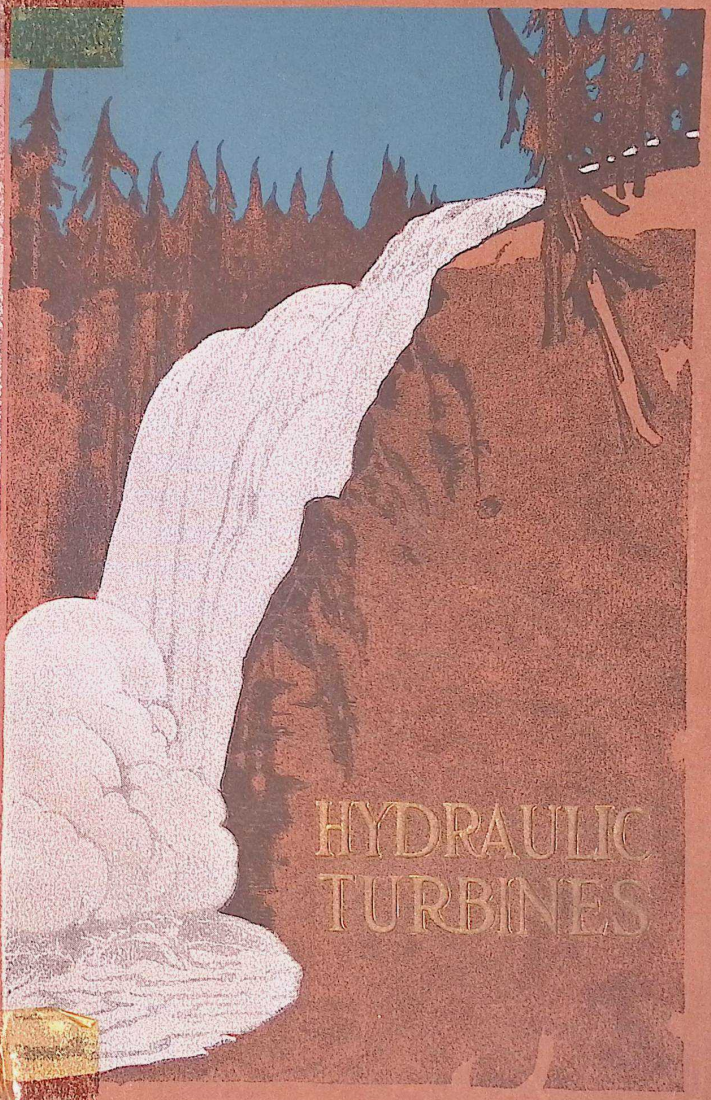
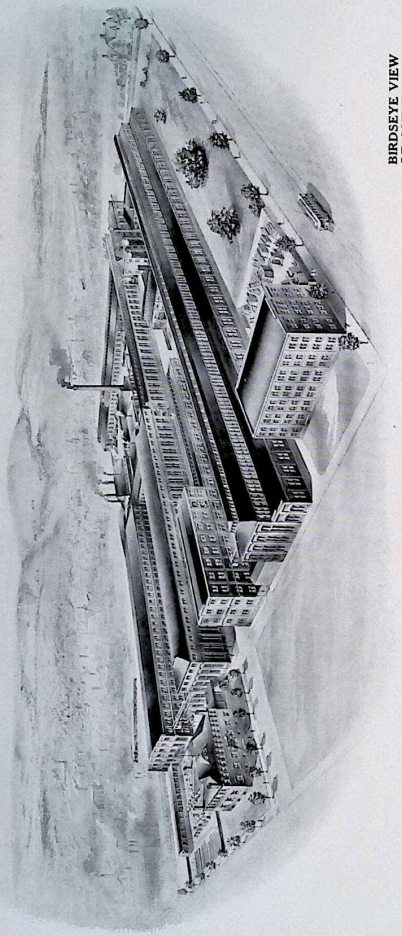

HYDRAULIC
TURBINES



BIRDSEYE VIEW
OF OUR WORKS

Bulletin 104 March, 1913

Smith Turbines

Manufactured by

S. Morgan Smith Co.

York, Pa., U. S. A.

Branch Offices:

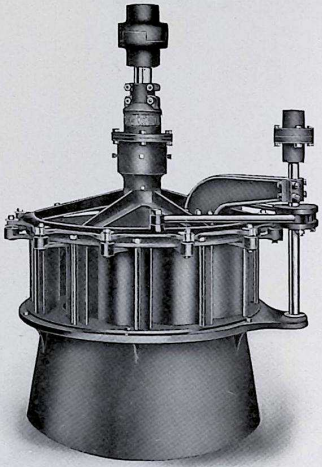
176 Federal Street,
Boston, Mass.

644 American Trust Bldg.,
Chicago, Ill.

Cable Address
"Success"

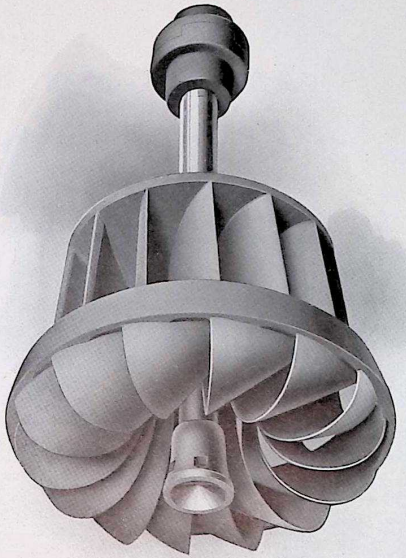
Codes: ABC 4th and 5th Edition
Liebers
Western Union

Copyright, 1913, by S. Morgan Smith Co.



Engraving No. 260

Represents a vertical "Smith" Wicket Gate Turbine fitted with our patented brass block gate operating mechanism, and with quarter box and safety step on the dome. The gate ring being operated by push and pull rods instead of gears.



Engraving No. 261

Represents the standard "Smith" runner with its shaft, coupling and cast iron step shoe. These runners are made either of solid cast iron or bronze, by means of cores, or can be furnished with plate steel buckets properly secured by cast iron hub and band. Attention is called to the openings for water cooling above the turned concave of the step shoe.

Preface

IN presenting this Bulletin to the public, we desire to call attention to the fact that while we have only published the tables of power and speed of the well known "Smith" turbines, we are building others of *greater power and higher speed*. We also continue to build the "McCormick," "New Success" and "Improved Success" turbines, and will furnish power tables of same upon application. We also build "Francis" turbines to operate under high heads, six hundred feet being the maximum. We have hundreds of patterns of *special capacity turbines*, which we have not tabled. Should none of our standard patterns meet the requirements, our engineers are prepared to design turbines that will. Therefore, we suggest that people having water powers to develop, or who may be considering a change in their present equipment, write us stating the head under which the turbines are to operate, the amount of power desired, or the water available, and if possible, the kind of machinery to be driven. This will enable us to select a turbine to meet the requirements.

We also call attention to the fact that all guarantees of power and speed of turbines of our manufacture are based on tests of turbines of similar design made in the testing flume of the Holyoke Water Power Company, Holyoke, Mass. We suggest that before selecting turbines, purchasers satisfy themselves

that those they are considering have been tested at the Holyoke testing flume and give the efficiency, power and speed guaranteed.

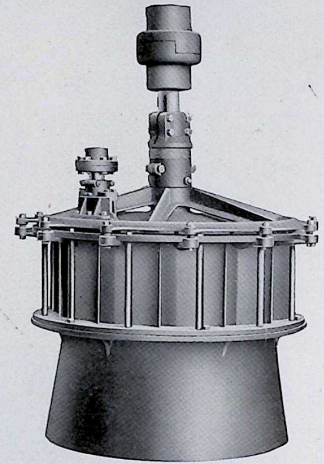
We have spared no expense in developing turbines which, while simple in design, give *high efficiency, speed and enormous power*.

The "Smith" and "McCormick" turbines can be furnished with either wicket or cylinder gates. The "Success" turbines are equipped with wicket gates only.

Our shops, located directly on the lines of the Pennsylvania and Western Maryland Railroads, are equipped with modern tools, and specially arranged for the handling of heavy machinery.

Those contemplating the purchase of turbines and machinery will find it to their interest to correspond with us, and if possible, call at the main office and go through our plant. *We will guarantee results when our instructions are followed.*

S. MORGAN SMITH CO.
York, Pa.

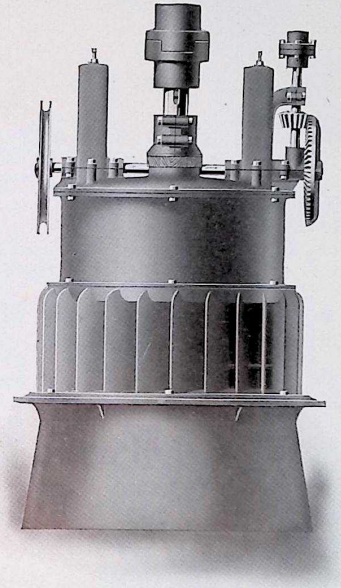


Engraving No. 262

Represents the standard "Smith" Wicket Gate Turbine. All prices quoted are for turbines of this design unless otherwise specified. All turbines 24" and under will be shipped together ready to be placed in the flume. Larger sizes will be shipped in sections for convenience in handling.

Prices on both Horizontal and Vertical Shaft Turbines will be quoted on application.

When comparing cost of different makes of Turbines do not fail to also compare the power and speed.



Engraving No. 263

On account of the simplicity of the Cylinder Gate some people have a preference for that type of wheel, and to meet this demand we build a line of "Smith" Turbines equipped with Cylinder gates, as shown by Engraving above. With this type of gate, the turbine develops the same power and speed as the Standard "Smith" Wicket Gate Turbines and very high efficiency. **This is the only Cylinder gate turbine the gate shaft of which can be removed without disturbing the dome lid.** The value of this improvement is appreciated when the spur pinions and racks which move the gate must be replaced.

Directions for Setting Wheels

In setting the "Smith" Turbine in a wooden penstock, the first thing to do is to see that the floor of the flume is level. Generally a ring made of soft wood is placed on the floor around the hole, on which the draft tube flange of the wheel, which is faced off, is set. It is very important that the flume be built on good foundations so as not to settle when the water is let in; a very good plan, and especially where large turbines are to be set, is to put four posts or iron columns under the timbers around the hole in the floor through which the draft tube passes.

The step and all bearings of the turbines are carefully adjusted before leaving the shops.

When turbines are shipped "knocked down," the draft tube should always be set in position first, then the runner or wheel proper placed on the step, then set the case and so on until all parts are together. When the step is properly adjusted, there will be a space between the top of the band of the runner and the bottom or inner edge of the bottom plate of $\frac{1}{32}''$. When the turbines are not to be run for some time, the steps and step shoes should be well covered with tallow to prevent rusting.

WARRANTY

Turbines installed in accordance with our instructions and operated at speeds recommended by us, for each installation, failing to give the power guaranteed by us, can be returned if not broken, to the station to which they were shipped any time within thirty days, and the money received for such wheels will be refunded. If purchaser finds it impossible to put the turbine in and give it a trial within the thirty days allotted, and wants more time it will be granted on application, not exceeding in all sixty days from date of shipment.

S. MORGAN SMITH COMPANY.

Test and Tables of the "Smith"

The tables of the "Smith" turbines are based on actual tests made in the Holyoke Testing Flume—the only reliable testing flume in the country. Both right and left hand turbines have been tested and brought to over 80 per cent. efficiency. Although our tables are only based on 80 per cent. useful effect from the water used, all of the turbines have exceeded 80 per cent. in the tests, some sizes having given over 90 per cent. at less than full gate with a very high average from half to full gate.

When comparing the tables of the "Smith" turbines with those of other manufacturers, satisfy yourself that the tables of those turbines are reliably made. Many turbine builders have tabled their turbines at 80 or even 90 per cent., when if the truth were known, their turbines in actual test would not exceed 60 to 70 per cent.

Before purchasing a turbine be assured that the tables of the particular size turbine you require are based on actual tests made in a new flume of the Holyoke Water Power Company. Water powers are becoming more valuable each year, and the owners of water powers cannot afford to run turbines which sacrifice water and give but little power.

The following rule will enable you to determine the percentage at which any turbine is tabled.

RULE

Multiply the cubic feet of water by 62½, which is the weight of one cubic foot of water; multiply the product by the head, which will give the foot pounds; divide that product by 33,000, which gives the full horse power of the water; divide the horse power claimed by the full horse power of the water, and the result will be the percentage at which the turbine is tabled.

Directions for the Construction of Head and Tail Races

THE HEAD RACE

In constructing the canal or head race, a very frequent error is committed by failing to give it sufficient capacity. It should be wide and deep, and especially where the race is of considerable length, and a large quantity of water is to pass through it. As a general rule, the water should not flow faster than from 60 to 120 feet per minute. Where there is a long race, after the turbine has been running three or four hours the head frequently draws down from one to three feet. The effect of this is the same as if the dam had been lowered an equal distance—resulting in a loss of power, which would have been prevented by making the race as wide and deep as it should be.

When the water is to be conveyed through pipes to the turbines operating under low heads, the receiving ends of the pipes should be well submerged so as to prevent any possibility of their drawing air. The velocity of the water through the pipes should not exceed three feet per second for short pipes, and as the length of the pipe increases, the velocity should be reduced until in pipes 200 to 250 feet in length, the velocity should not exceed two feet per second. It is, however, often necessary to run the water at higher velocities. See table giving the loss of head in pipes of different sizes at various velocities on pages 64 and 65.

THE TAIL RACE

This should be wide and deep, and the level of the bottom of the wheel pit should be carried from five to ten feet below the end of the flume, and if possible it should be carried out to the bed of the stream, as no tail race for even small turbines should have less than two feet of dead water in it before the turbines are put in motion, and where large turbines (using considerable water) are to be used, the tail race should have three or four feet of dead water in its entire length. By having the tail race thus constructed, as soon as the water is discharged from the turbines, it will push out or displace the dead water in the race, thus preventing a loss of head. For instance, to be more explicit, suppose the bottom of tail race is on a level with

the water in main stream into which the tail race discharges, when the turbines are started the water in tail race would rise in proportion to the width of the race and the quantity of water flowing therein, and reduce the working head in proportion; while if the race were as first above stated, the water from the turbines would displace the dead water without rising above the water in the main stream, thus utilizing the full amount of head. From one to three feet of working head is often lost for want of proper depth and width of tail race.

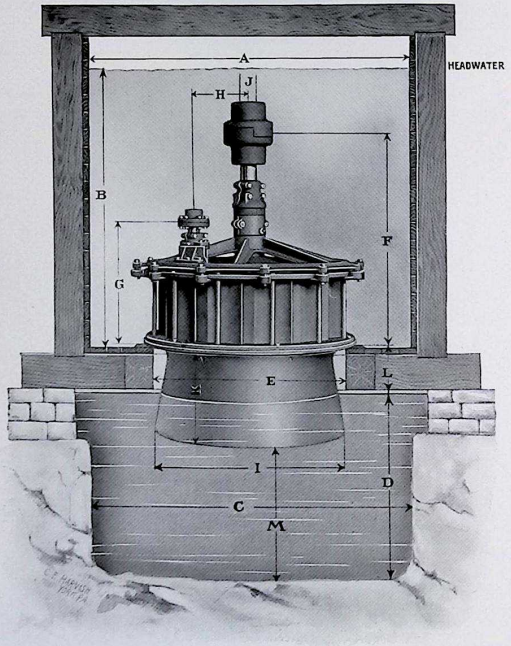
WHEEL PIT

Here is where mill owners and millwrights, in putting in turbines are more liable to err than elsewhere. Whether under high or low heads, the pit should be deep and wide. There is no case where this is more important than where a large turbine is run under a low head; as under these circumstances it is not desirable to lose any head whatever. A pit of insufficient size causes the water to react upon the turbine, and an additional loss of power is also caused by the fact that a portion of the head is consumed in forcing the water out of the pit when there is not sufficient outlet. As a rule, the depth of the pit should not be less than the diameter of the lower end of the draft tube.

Water has but 100 per cent. in it, and a turbine that takes out from 80 to 90 of that per cent. leaves but little force in it. To expect that the water coming through our turbines will have power to wash the sand and gravel out of its own pit, is to expect what will not be realized. Hence in putting in turbines, do not calculate upon the water in the wheel pit to do any work. If you find it foaming and dashing in the pit, then rest assured that the pit is either too shallow or too narrow, or both.

SETTING TURBINES ABOVE TAIL WATER

Sometimes in adapting turbines to high and even low heads, it becomes necessary to set the turbine some distance above the tail water and conduct the water from the turbine through a draft tube. Better results may be obtained when the turbine is set in this manner than if it is placed close to the tail water, provided the draft tube is air tight and its discharge end properly submerged. In all cases when a draft tube is used, it should be made of steel or concrete.



Engraving No. 264

Shows Wicket Gate Turbine in wooden flume.
See dimensions on page 15.

Dimensions of Turbines and Penstocks

IN INCHES

Lettered columns correspond with letters in engraving on opposite page.

Dia. Turbine	A	B	C	D	E	F	G	H	I	J	K	L	M
12	42	36	48	32	21	25	14	7	20	2 1/8	9 3/16	5 5/8	26
15	48	42	54	36	26	28	16 3/4	9 1/16	24 1/16	2 3/8	12	6	30
18	54	45	63	41	30 1/2	30	17 3/4	10 1/16	29 1/2	2 5/8	14 1/2	8 1/2	35
21	63	48	72	46	35 1/4	35	21 3/8	12 1/16	34 1/4	3 1/8	16 1/2	10 1/2	40
24	72	52	84	51	39	40	23	14 3/8	38	3 3/8	18	12	45
27	84	56	90	57	43	42	25 1/16	16 1/2	42	3 5/8	19	12	50
30	90	60	102	63	47	49	28	18 1/2	45 3/4	3 7/8	20 1/2	12 1/2	55
33	102	64	108	68	52	54	31 5/8	21 1/8	50 5/8	4 1/8	23	15	60
36	108	68	120	73	57	54 1/2	32 3/4	23	56	4 3/8	25	16	64
39	120	72	126	77	61 1/2	55	34	24 3/4	60 1/2	5 1/8	27	18	68
42	126	76	138	81	65 1/2	61	37	26	64 1/8	5 3/8	28 3/4	19 3/4	72
45	138	80	144	86	70 1/2	66	38 5/8	28	69 1/2	5 7/8	31 3/4	21 3/4	76
48	144	84	153	90	75 1/2	72	40 3/16	29 3/4	74	6 1/8	34 3/4	24 3/4	80
51	153	88	162	97	79	76	43 7/8	31 3/4	78 1/2	6 7/8	37	26	86
54	162	92	168	104	84	80	45 1/4	33	82 1/2	7 1/8	39	27	92
57	168	96	180	110	87	84	48 5/8	. . . .	85 1/2	7 7/8	41	29	98
60	180	100	192	118	93	87	51 3/8	. . . .	91 1/8	7 7/8	43	31	106
63	192	104	204	124	98	90	53 3/4	. . . .	96 3/8	7 7/8	44 1/2	32 1/2	112
66	204	108	214	130	103	93	56 3/8	. . . .	102 3/8	7 7/8	46	34	118
69	208	110	220	133	106	94	59	. . . .	105 5/8	7 7/8	47	35	121
72	214	112	226	136	110 1/2	96	61 1/2	. . . .	108 5/8	7 7/8	48	36	124

Some of the Most Important Advantages of the "Smith" Turbine

It develops the largest amount of power for a given amount of water of any turbine manufactured.

It will not clog with trash, as anything that will pass through the gates will pass through the runner.

It runs at the highest speed ever attained by a turbine, thus avoiding the necessity of gearing up when driving fast running machinery.

It develops enormous power for its diameter, thus reducing the cost of flumes.

It is so constructed that there is very little pressure on the steps.

Its gates are practically balanced, thus requiring a minimum effort to control same.

It has proven its superiority by actual tests in the Holyoke testing flume.

Tables of "Smith" Turbines

WE BUILD TURBINES OF GREATER CAPACITY THAN THE FOLLOWING TABLES.

Diameter of Wheel in Inches.	Horse Power, Cubic Feet Discharged, Revolutions per Minute.	HEAD IN FEET. 3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
12	Horse Power	1.7	2.7	3.7	4.9	6.2	7.6	9.1	10.6	12.3	14.0	15.8	17.7	19.6	21.6	23.7
	Cubic Feet	370	441	483	533	579	621	660	693	731	762	794	826	853	882	911
	Revolutions	240	277	310	340	367	392	416	438	460	480	500	519	537	554	572
15	Horse Power	2.7	4.2	5.9	7.8	9.8	12.0	14.4	16.8	19.4	22.1	25.0	27.9	31.0	34.1	37.4
	Cubic Feet	488	686	771	850	915	980	1045	1098	1153	1204	1257	1303	1351	1393	1438
	Revolutions	192	222	248	271	293	314	333	351	368	384	400	416	430	444	457
18	Horse Power	3.9	6.0	8.5	11.1	14.0	17.2	20.5	24.0	27.7	31.6	35.6	39.8	44.1	48.6	53.3
	Cubic Feet	750	980	1111	1209	1307	1405	1489	1569	1646	1721	1790	1858	1921	1985	2049
	Revolutions	160	185	207	226	244	261	277	292	306	320	333	346	358	370	381
21	Horse Power	5.3	8.2	11.5	15.2	19.1	23.3	27.9	32.7	37.7	43.0	48.4	54.1	60.0	66.2	72.5
	Cubic Feet	1155	1340	1503	1655	1783	1903	2026	2135	2240	2342	2433	2526	2614	2704	2788
	Revolutions	137	158	177	194	210	224	238	251	263	274	285	296	307	317	327
24	Horse Power	7.0	10.8	15.1	19.8	25.0	30.6	36.5	42.7	49.3	56.2	63.4	70.8	78.6	86.6	94.8
	Cubic Feet	1525	1765	1974	2156	2334	2500	2651	2791	2929	3061	3188	3306	3426	3537	3645
	Revolutions	120	139	155	170	183	196	208	219	230	240	250	259	268	277	286
27	Horse Power	8.9	13.6	19.1	25.1	31.7	38.7	46.2	54.1	62.4	71.1	80.2	89.6	99.4	109.5	119.9
	Cubic Feet	1939	2222	2497	2734	2960	3162	3355	3535	3708	3873	4032	4183	4331	4472	4610
	Revolutions	107	123	138	151	163	174	185	195	204	213	222	231	239	247	254
30	Horse Power	10.9	16.9	23.6	31.0	39.1	47.8	57.0	66.8	77.1	87.8	99.0	110.7	122.7	135.2	148.1
	Cubic Feet	2375	2761	3085	3377	3651	3905	4139	4366	4581	4782	4978	5168	5346	5521	5695
	Revolutions	96	111	124	136	147	157	166	175	184	192	200	207	215	222	229
33	Horse Power	13.2	20.4	28.6	37.6	47.3	57.9	69.0	80.9	93.3	106.3	119.9	134.0	148.6	163.7	179.3
	Cubic Feet	2876	3333	3738	4101	4421	4728	5010	5287	5543	5787	6028	6256	6474	6686	6894
	Revolutions	87	101	113	123	133	143	151	159	167	175	182	189	196	202	208
36	Horse Power	15.8	24.3	33.9	44.8	56.4	68.9	82.2	96.3	111.1	126.6	142.8	159.6	177.0	195.0	213.5
	Cubic Feet	3442	3971	4431	4880	5266	5629	5969	6294	6601	6896	7180	7452	7712	7964	8209
	Revolutions	80	92	103	113	122	131	140	147	154	160	167	173	179	185	191
39	Horse Power	19.5	28.5	39.9	52.5	66.1	80.8	96.4	112.9	130.3	148.5	167.4	187.1	207.5	228.6	250.4
	Cubic Feet	4248	4657	5216	5719	6172	6601	7001	7379	7742	8089	8417	8736	9041	9336	9628
	Revolutions	74	85	95	104	113	121	128	135	141	148	154	159	165	171	176

WE ALSO BUILD REDUCED CAPACITY TURBINES.

Tables of "Smith" Turbines

TURBINES OF INCREASED POWER AND SAME SPEED CAN BE FURNISHED.

Diameter of Wheel in inches.	Horse Power, Cubic Feet Discharged, Revolutions per Minute.	HEAD IN FEET. 3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
42	Horse Power	21.5	33.1	46.3	60.8	76.7	93.7	111.8	131.0	151.1	172.2	194.2	217.0	240.7	265.1	290.4
	Cubic Feet	4684	5408	6052	6623	7151	7655	8119	8562	8978	9381	9764	10133	10487	10827	11166
	Revolutions	69	79	88	97	105	112	119	125	131	137	143	148	153	158	163
45	Horse Power	24.7	38.0	53.1	69.8	88.0	107.5	128.3	150.3	173.3	197.5	222.7	248.9	276.1	304.1	333.1
	Cubic Feet	5381	6209	6941	7603	8217	8783	9317	9837	10297	10758	11187	11621	12030	12419	12808
	Revolutions	64	74	83	91	98	105	111	117	123	128	133	138	143	148	152
48	Horse Power	27.8	42.9	59.9	78.8	99.2	121.3	144.7	169.5	195.6	222.8	251.3	280.9	311.5	343.2	375.8
	Cubic Feet	6057	7010	7831	8584	9262	9910	10508	11068	11622	12136	12635	13115	13572	14016	14450
	Revolutions	60	69	77	85	92	98	104	110	115	119	124	129	134	139	143
51	Horse Power	31.7	48.8	68.3	89.8	113.2	138.3	165.0	193.2	222.9	254.0	286.4	320.1	355.0	391.1	428.3
	Cubic Feet	6906	7974	8928	9782	10569	11308	11982	12629	13245	13835	14400	14945	15467	15972	16488
	Revolutions	56	65	73	80	86	92	98	103	108	113	118	122	126	130	134
54	Horse Power	35.6	54.8	76.5	100.6	126.8	155.0	184.9	216.6	249.8	284.7	321.0	358.8	397.9	438.4	480.1
	Cubic Feet	7756	8954	10000	10958	11839	12663	13427	14157	14843	15508	16140	16752	17336	17904	18480
	Revolutions	53	62	69	75	81	87	92	97	102	107	111	115	119	123	127
57	Horse Power	39.6	61.0	85.3	112.1	141.3	172.7	206.0	241.3	278.4	317.2	357.7	399.8	443.4	488.5	535.0
	Cubic Feet	8627	9967	11150	12211	13193	14110	14959	15771	16543	17278	17988	18667	19319	19950	20570
	Revolutions	51	58	65	71	77	83	88	93	97	101	105	109	113	117	121
60	Horse Power	43.9	67.6	94.5	124.2	156.6	191.4	228.3	267.4	308.5	351.5	396.4	443.0	491.3	541.2	592.8
	Cubic Feet	9564	11046	12353	13529	14622	15637	16579	17477	18331	19146	19931	20683	21406	22106	22793
	Revolutions	48	55	62	68	73	78	83	88	92	96	100	104	108	111	114
63	Horse Power	48.4	74.5	104.2	137.0	172.7	211.0	251.7	294.8	340.1	387.5	437.0	488.4	541.6	596.7	653.5
	Cubic Feet	10545	12173	13621	14923	16125	17239	18278	19268	20209	21107	21972	22792	23597	24369	25117
	Revolutions	46	53	59	65	70	75	79	84	88	92	95	99	103	106	109
66	Horse Power	53.1	81.8	114.4	150.3	189.5	231.5	276.3	323.5	373.3	425.3	479.6	536.0	594.4	654.9	717.2
	Cubic Feet	11569	13366	14954	16372	17694	18914	20065	21146	22181	23166	24114	25026	25898	26746	27566
	Revolutions	44	50	56	62	67	71	76	80	83	87	91	94	97	101	104
72	Horse Power	63.2	97.4	136.1	178.9	225.5	275.6	328.8	385.1	444.2	506.2	570.8	637.9	707.5	779.4	853.6
	Cubic Feet	13769	15915	17791	19487	21055	22516	23877	25170	26394	27573	28700	29783	30826	31830	32821
	Revolutions	40	46	52	57	61	66	70	73	77	80	83	86	89	92	95

SPECIAL TURBINES DESIGNED FOR ANY HEAD.

Tables of "Smith" Turbines

IF THE TURBINES TABLED ARE NOT POWERFUL ENOUGH OUR NEW TURBINES WILL BE

Diameter of Wheel in Inches	Horse Power, Cubic Feet Discharged, Revolutions per Minute.	HEAD IN FEET. 18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
12	Horse Power	25.8	28.0	30.2	32.5	34.9	37.3	39.7	42.2	44.8	47.4	50.1	52.8	55.5	58.3	61.2
	Cubic Feet	937	963	987	1011	1037	1060	1081	1103	1126	1147	1169	1190	1209	1229	1250
	Revolutions	588	604	620	635	650	665	679	693	707	720	733	746	759	772	784
15	Horse Power	40.7	44.2	47.7	51.3	55.0	58.8	62.7	66.7	70.7	74.9	79.1	83.3	87.7	92.1	96.6
	Cubic Feet	1478	1520	1559	1596	1634	1671	1707	1744	1777	1813	1846	1878	1911	1941	1972
	Revolutions	470	483	496	508	520	532	543	554	565	576	587	597	607	617	627
18	Horse Power	58.0	62.9	68.0	73.1	78.4	83.8	89.4	95.0	100.8	106.6	112.6	118.7	124.9	131.1	137.6
	Cubic Feet	2106	2164	2222	2275	2329	2382	2435	2484	2534	2581	2628	2675	2722	2764	2810
	Revolutions	392	403	413	423	433	443	453	462	471	480	489	498	506	515	523
21	Horse Power	79.0	85.6	92.5	99.5	106.7	114.0	121.6	129.2	137.1	145.1	153.2	161.5	169.9	178.5	187.2
	Cubic Feet	2868	2944	3023	3096	3170	3240	3311	3377	3446	3513	3576	3640	3702	3760	3822
	Revolutions	336	345	354	363	372	380	388	396	404	412	420	427	434	441	448
24	Horse Power	103.3	112.0	121.0	130.3	139.6	149.2	159.0	169.1	179.4	189.8	200.4	211.3	222.3	233.5	244.9
	Cubic Feet	3751	3853	3954	4055	4148	4240	4330	4420	4510	4595	4677	4763	4844	4922	5000
	Revolutions	294	302	310	318	325	332	339	346	353	360	367	374	380	386	392
27	Horse Power	130.6	141.7	153.0	164.7	176.5	188.7	201.1	213.8	226.8	240.0	253.5	267.2	281.1	295.3	309.7
	Cubic Feet	4742	4874	5000	5125	5244	5363	5476	5588	5702	5810	5917	6023	6125	6226	6324
	Revolutions	261	268	275	282	289	295	302	308	314	320	326	332	337	343	348
30	Horse Power	161.4	174.9	189.0	203.3	218.1	233.1	248.5	264.1	280.2	296.5	313.1	330.0	347.2	364.8	382.6
	Cubic Feet	5860	6016	6176	6327	6480	6625	6767	6903	7044	7178	7308	7438	7565	7690	7813
	Revolutions	235	242	248	254	260	266	272	277	283	288	293	299	304	309	314
33	Horse Power	195.3	211.8	228.8	246.2	263.9	282.1	300.7	319.7	339.1	358.9	379.0	399.5	420.3	441.5	463.0
	Cubic Feet	7091	7285	7475	7661	7840	8017	8188	8356	8524	8688	8845	9004	9158	9305	9454
	Revolutions	214	220	226	231	237	242	247	253	258	263	267	272	277	281	286
36	Horse Power	232.6	252.3	272.5	293.2	314.4	336.1	358.3	380.9	404.0	427.5	451.5	475.9	500.7	526.0	551.6
	Cubic Feet	8446	8679	8905	9124	9340	9552	9756	9957	10156	10350	10538	10727	10910	11088	11263
	Revolutions	196	201	206	211	217	222	227	232	236	240	244	248	253	257	261
39	Horse Power	272.8	295.9	319.5	343.8	368.7	394.1	420.1	446.6	473.7	501.2	529.3	558.0	587.0	616.7	646.8
	Cubic Feet	9905	10179	10441	10699	10954	11200	11439	11674	11909	12134	12354	12577	12791	13000	13208
	Revolutions	181	186	191	195	200	205	209	213	217	222	226	230	234	238	241

FRANCIS TURBINES FURNISHED FOR HEADS UP TO 600 FEET.

Tables of "Smith" Turbines

TURBINES WITH GREATLY INCREASED POWER AND SPEED CAN BE FURNISHED

Diameter of Wheel in Inches	Horse Power, Cubic Feet Discharged, Revolutions per Minute.	HEAD IN FEET. 18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
42	Horse Power	316.4	343.1	370.5	398.7	427.5	457.0	487.1	517.9	549.3	581.3	613.8	647.0	680.8	715.1	750.0
	Cubic Feet	11488	11803	12108	12408	12701	12987	13264	13538	13809	14073	14326	14583	14835	15074	15315
	Revolutions	168	173	178	182	186	190	194	198	202	206	209	213	217	221	224
45	Horse Power	362.9	393.6	425.1	457.3	490.4	524.2	558.8	594.1	630.1	666.8	704.2	742.2	780.9	820.3	860.2
	Cubic Feet	13177	13540	13892	14231	14570	14898	15216	15530	15841	16143	16436	16729	17016	17292	17565
	Revolutions	157	161	165	169	173	177	181	185	189	193	196	199	202	206	209
48	Horse Power	409.5	444.1	479.6	516.0	553.3	591.5	630.4	670.3	710.9	752.3	794.5	837.3	881.1	925.5	970.7
	Cubic Feet	14869	15277	15673	16058	16438	16810	17166	17521	17872	18213	18543	18872	19199	19509	19822
	Revolutions	147	151	155	159	163	166	169	173	176	180	183	186	190	193	196
51	Horse Power	466.7	506.2	546.6	588.1	630.6	674.1	718.6	763.9	810.2	857.4	905.5	954.5	1004.2	1054.9	1106.3
	Cubic Feet	16946	17413	17863	18301	18735	19158	19567	19968	20368	20757	21134	21514	21881	22237	22590
	Revolutions	138	142	146	150	153	156	159	163	166	169	173	176	179	182	185
54	Horse Power	523.0	567.3	612.6	659.2	706.8	755.5	805.3	856.2	908.1	961.0	1014.8	1069.7	1125.5	1182.3	1239.9
	Cubic Feet	18990	19515	20020	20514	20999	21471	21928	22371	22829	23266	23685	24111	24524	24923	25318
	Revolutions	131	134	137	140	144	147	150	154	157	160	163	166	169	172	174
57	Horse Power	582.8	632.1	682.6	734.5	787.6	841.9	897.4	954.0	1011.9	1070.8	1130.8	1192.0	1254.1	1317.4	1381.6
	Cubic Feet	21161	21744	22307	22857	23399	23926	24436	24937	25439	25924	26393	26868	27327	27771	28212
	Revolutions	124	127	130	133	136	140	143	146	149	152	155	157	160	163	165
60	Horse Power	645.8	700.4	756.4	813.9	872.7	932.9	994.4	1057.0	1121.2	1186.5	1253.0	1320.8	1389.7		
	Cubic Feet	23449	24094	24719	25328	25928	26513	27077	27630	28187	28725	29245	29771	30281		
	Revolutions	117	121	124	127	130	133	136	139	142	145	147	150	152		
63	Horse Power	712.0	772.2	833.9	897.3	962.1	1028.5	1096.3	1165.5	1236.1	1308.1	1381.5	1456.2	1532.1		
	Cubic Feet	25852	26563	27252	27924	28584	29230	29852	30466	31075	31669	32244	32833	33384		
	Revolutions	112	115	118	121	124	127	129	132	135	138	140	142	144		
66	Horse Power	781.4	847.5	915.2	984.8	1055.9	1128.7	1203.1	1279.1							
	Cubic Feet	28372	29154	29908	30647	31370	32077	32760	33435							
	Revolutions	107	110	113	116	119	121	124	126							
72	Horse Power	930.0	1008.7	1089.2	1172.0	1256.7	1343.3	1431.9	1522.3							
	Cubic Feet	33768	34699	35595	36472	37336	38176	38990	39792							
	Revolutions	98	101	103	106	108	111	113	115							

WE FURNISH SLOW SPEED TURBINES WHEN REQUIRED.

Tables of "Smith" Turbines

OUR INCREASED CAPACITY TURBINES WILL MEET CONDITIONS WHEN STANDARD TURBINES DO NOT.

Diameter of Wheel in Inches.	Horse Power, Cubic Feet Discharged, Revolutions per Minute.	HEAD IN FEET. 33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
12	Horse Power	64.1	67.0	70.0	73.0	76.1	79.2	82.3	85.5	88.0	91.2	94.5	98.4	101.1	104.4	108.0
	Cubic Feet	1270	1288	1307	1326	1345	1362	1379	1397	1403	1419	1436	1461	1468	1483	1502
	Revolutions	796	808	820	832	843	854	865	876	887	897	908	919	929	939	949
15	Horse Power	101.2	105.8	110.5	115.3	120.1	125.0	130.0	135.0	139.4	144.6	149.8	155.2	160.3	165.7	171.1
	Cubic Feet	2005	2033	2063	2094	2122	2150	2179	2206	2222	2250	2277	2304	2327	2354	2380
	Revolutions	637	647	656	665	675	684	693	701	710	719	728	736	744	753	761
18	Horse Power	144.1	150.7	157.4	164.2	171.1	178.1	185.2	192.3	199.2	206.5	214.0	221.6	229.1	236.7	244.5
	Cubic Feet	2855	2896	2939	2982	3023	3063	3104	3142	3175	3213	3253	3291	3326	3363	3401
	Revolutions	531	539	547	555	562	569	577	584	591	598	605	612	619	626	633
21	Horse Power	196.0	205.0	214.1	223.4	232.8	242.2	251.9	261.6	271.4	281.4	291.5	301.6	312.1	322.6	333.1
	Cubic Feet	3882	3940	3997	4057	4114	4166	4222	4275	4326	4378	4430	4478	4533	4583	4633
	Revolutions	455	462	469	475	482	488	494	500	507	514	520	526	532	538	544
24	Horse Power	256.5	268.2	280.1	292.2	304.5	316.9	329.5	342.3	354.4	367.5	380.7	394.4	407.6	421.3	435.0
	Cubic Feet	5081	5155	5229	5306	5380	5450	5522	5593	5649	5718	5786	5857	5918	5986	6051
	Revolutions	398	404	410	416	422	427	432	437	443	449	454	460	465	470	475
27	Horse Power	324.3	339.2	354.3	369.6	385.1	400.8	416.7	432.8	449.1	465.6	482.3	499.2	516.4	533.7	551.2
	Cubic Feet	6424	6519	6615	6712	6805	6894	6984	7072	7158	7244	7330	7413	7498	7583	7667
	Revolutions	354	359	364	370	375	380	385	390	395	400	404	409	414	418	422
30	Horse Power	400.6	419.0	437.6	456.5	475.7	495.1	514.7	534.7	554.5	574.9	595.6	616.8	637.6	659.0	680.6
	Cubic Feet	7936	8053	8170	8290	8406	8516	8626	8737	8838	8945	9053	9159	9264	9364	9467
	Revolutions	319	323	327	333	337	342	346	351	355	360	364	368	372	376	380
33	Horse Power	484.9	507.1	529.7	552.5	575.7	599.2	623.0	647.1	671.6	696.3	721.3	746.4	772.2	798.1	824.3
	Cubic Feet	9605	9746	9889	10033	10172	10306	10441	10573	10705	10834	10963	11084	11212	11341	11466
	Revolutions	290	295	299	303	307	312	316	320	323	327	330	334	337	341	344
36	Horse Power	577.7	604.1	631.0	658.2	685.8	713.8	742.2	770.9	799.4	828.8	858.6	888.8	919.2	950.0	981.2
	Cubic Feet	11444	11611	11781	11964	12118	12277	12439	12596	12742	12896	13050	13186	13346	13499	13648
	Revolutions	265	269	273	277	281	285	289	292	296	300	304	308	312	315	319

IF TURBINES TABLED DO NOT MEET CONDITIONS, OUR SPECIAL PATTERNS WILL.

Tables of "Smith" Turbines

WILL FURNISH DATA ON INCREASED CAPACITY TURBINES ON APPLICATION.

Diameter of Wheel in Inches	Horse Power, Cubic Feet Discharged, Revolutions per Minute.	HEAD IN FEET. 33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
39	Horse Power	677.3	708.3	739.8	771.8	804.1	836.9	870.2	903.9	937.2	971.7	1006.6	1042.4	1077.7	1113.8	1150.3
	Cubic Feet	13417	13613	13812	14016	14208	14395	14584	14770	14939	15118	15300	15478	15648	15827	16000
	Revolutions	245	249	252	256	259	263	267	270	273	277	280	283	287	290	293
42	Horse Power	785.4	821.4	857.9	894.9	932.5	970.5	1009.1	1048.2	1087.5	1127.5	1168.0	1208.8	1250.5	1292.4	
	Cubic Feet	15559	15787	16017	16251	16477	16693	16913	17128	17334	17544	17753	17949	18157	18365	
	Revolutions	227	230	234	237	240	244	247	250	253	256	259	262	265	268	
45	Horse Power	901.0	942.2	984.1	1026.6	1069.7	1113.3	1157.5	1202.4	1247.7	1293.6	1340.1	1386.4	1434.9		
	Cubic Feet	17849	18110	18373	18643	18902	19149	19400	19647	19888	20128	20369	20588	20834		
	Revolutions	212	215	219	222	225	228	231	234	237	240	243	246	249		
48	Horse Power	1016.5	1063.1	1110.3	1158.3	1206.8	1256.1	1306.0	1356.4	1407.1	1458.9	1511.3	1564.8			
	Cubic Feet	20137	20433	20729	21034	21324	21605	21888	22153	22429	22700	22971	23237			
	Revolutions	199	202	205	208	211	214	217	219	222	225	228	231			
51	Horse Power	1158.6	1211.6	1265.5	1320.1	1375.5	1431.6	1488.5	1546.1	1603.9	1662.9	1722.7				
	Cubic Feet	22952	23287	23627	23973	24305	24623	24964	25289	25565	25874	26185				
	Revolutions	188	190	192	195	198	201	203	206	209	211	214				
54	Horse Power	1298.5	1358.0	1418.3	1479.6	1541.6	1604.5	1668.3	1732.9	1798.1	1864.3					
	Cubic Feet	25723	26100	26480	26869	27240	27597	27936	28315	28661	29008					
	Revolutions	177	180	182	185	187	190	192	195	197	199					
57	Horse Power	1446.9	1513.2	1580.4	1648.6	1717.8	1787.9	1858.9	1930.9	2003.2						
	Cubic Feet	28663	29084	29506	29938	30353	30753	31155	31550	31931						
	Revolutions	168	170	173	175	178	180	182	185	187						

In comparing the "Smith" with other turbines, bear in mind that these tables have been computed from tests of these turbines under the dynamometer at the Holyoke Testing Flume, and show actual performance when at work. Each size up to and including the 51" has been tested by the Holyoke Water Power Company, consequently the tables are authentic.

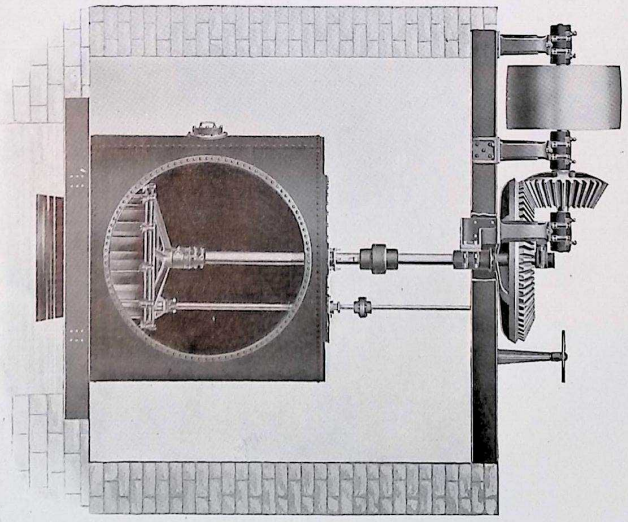
We do not care to compete with builders who have not had their turbines tested by the Holyoke Water Power Company, or those who have had only two or three sizes tested and guarantee other sizes to give equally as good results. The records of tests of "Smith" turbines are on file in our office and are open for inspection. For your protection do not purchase a turbine that has not been tested by recognized authorities.

Tables of "Smith" Turbines

INCREASED CAPACITY TURBINES TO MEET SPECIAL CONDITIONS CAN BE FURNISHED.

Diameter of Wheel in Inches.	Horse Power, Cubic Feet Discharged, Revolutions per Minute.	HEAD IN FEET.														
		48	49	50	51	52	53	54	55	56	57	58	59	60	61	62
12	Horse Power	112.0	115.8	119.3	122.8	126.4	130.2	134.0	137.7	141.6	145.3	149.3	153.0	156.8	160.8	164.8
	Cubic Feet	1525	1544	1559	1574	1589	1605	1621	1636	1652	1666	1682	1695	1707	1722	1737
	Revolutions	960	970	980	990	1000	1009	1018	1028	1038	1047	1055	1064	1074	1083	1092
15	Horse Power	176.8	182.9	188.6	194.3	200.0	205.7	211.8	217.6	223.2	229.5	235.6	241.8	248.0	254.0	260.3
	Cubic Feet	2408	2439	2465	2490	2514	2536	2562	2585	2604	2632	2655	2679	2700	2720	2743
	Revolutions	768	776	784	793	800	807	814	822	830	837	844	851	858	866	873
18	Horse Power	252.8	261.0	268.7	276.4	284.8	293.3	301.5	310.0	318.4	327.1	335.7	344.4	352.8	362.2	371.1
	Cubic Feet	3443	3481	3512	3543	3580	3616	3648	3683	3715	3752	3783	3816	3842	3879	3911
	Revolutions	640	646	653	660	666	672	679	685	691	697	704	710	716	722	728
21	Horse Power	344.0	354.7	365.4	376.1	387.2	399.0	410.4	421.5	432.8	445.0	456.7	468.4	480.0	492.7	504.8
	Cubic Feet	4685	4731	4776	4821	4867	4919	4965	5007	5050	5104	5147	5190	5227	5276	5320
	Revolutions	549	554	560	565	570	576	582	587	592	597	603	608	614	620	626
24	Horse Power	449.6	464.0	478.2	492.7	507.2	521.9	536.8	551.7	566.4	582.1	597.6	613.0	628.8	644.5	660.4
	Cubic Feet	6123	6189	6250	6316	6375	6435	6495	6554	6610	6676	6735	6792	6847	6902	6960
	Revolutions	480	485	490	495	500	505	509	513	518	523	527	531	536	540	545
27	Horse Power	568.8	586.7	604.7	623.1	641.6	660.0	678.8	697.6	716.4	736.1	755.7	775.1	795.2	814.9	835.0
	Cubic Feet	7757	7826	7903	7988	8064	8137	8213	8287	8360	8443	8516	8588	8659	8727	8800
	Revolutions	426	430	435	439	444	448	453	457	462	466	470	474	478	482	486
30	Horse Power	702.4	724.7	746.9	769.2	792.0	815.3	838.6	861.7	885.6	909.3	933.3	957.4	981.6	1006.7	1031.6
	Cubic Feet	9566	9667	9762	9861	9955	10052	10147	10236	10334	10429	10518	10607	10689	10781	10873
	Revolutions	384	388	392	396	399	403	407	411	415	419	423	427	430	433	437

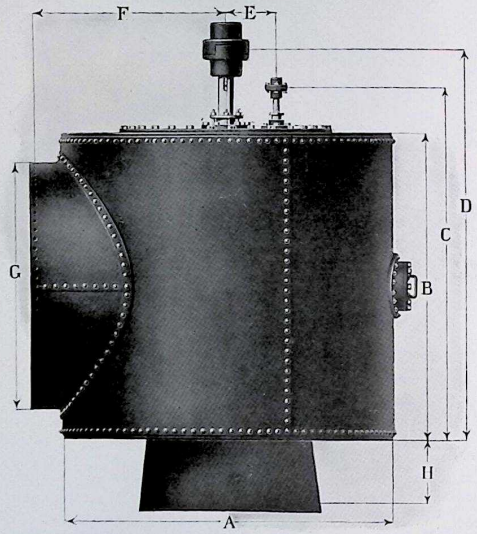
The revolution and water consumption of a turbine vary as the square root of the head ($\sqrt{H}$) and the power varies as the square root of the cube of the head ($\sqrt{H^3}$). This means that for a turbine when the head is multiplied by four the speed and water used per minute will be multiplied by two and the power multiplied by eight. Example: a 12″ turbine under 12 ft. head develops 14 H.P. at 480 revolutions, using 762 cubic feet water per minute. (See table under 12 ft. head). This same turbine under 48 ft. head would develop 112 H.P. at 960 revolutions, using 1,524 cubic feet water per minute, according to the above rule (see table under 48 ft. head).



Engraving No. 265

Represents a vertical shaft turbine in steel flume. The design for supporting the gears, pulley, vertical and horizontal shafts is first class in every particular. This makes a very compact and economical installation.

Iron Flumes for Turbines



Engraving No. 266

The cost of steel flumes usually exceeds that of those constructed of wood, but for many installations they are more desirable on account of their durability and freedom from leakage.

Each flume has a heavy cast iron top and bottom, also a cover plate of sufficient size to admit the turbine, and is fitted with packing boxes for turbine and gate shafts. The main body of the flume and the inlet are of plate steel.

A man door is conveniently located on the side of the flume affording easy access to the turbine. See dimensions of flumes on opposite page.

S. MORGAN SMITH COMPANY

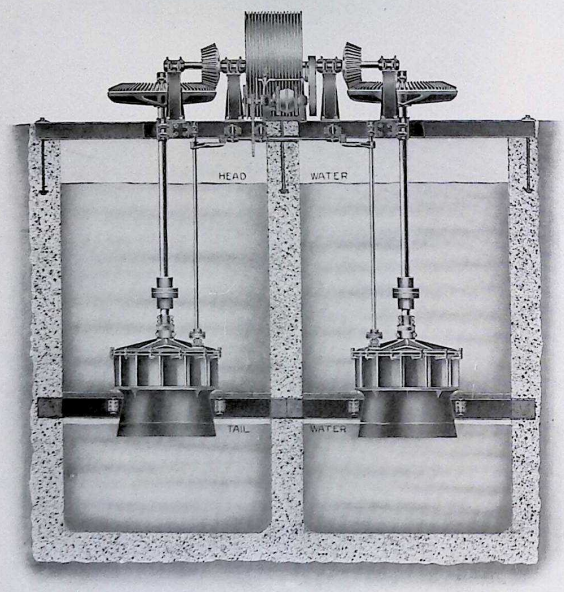
Dimensions of Iron Flumes

IN INCHES

Lettered columns correspond with letters in engraving on opposite page.

Dia. of Wheel	A	B	C	D	E	F	G	H
9								
12	36	36	53¼	61¼	7	22	24	8⅜
15	45	42	59¼	67¼	9⅛	28	30	10¾
18	54	48	65¼	73¼	10 1/16	32	36	13¼
21	60	54	71½	79½	12 1/16	34	42	15
24	72	60	75½	85½	14⅜	40	48	16½
27	78	72	89½	97½	16½	42	54	17
30	84	76	93½	103½	18½	46	60	19
33	96	82	103¾	113¾	21⅛	52	66	21¼
36	102	90	111¾	121¾	23	56	75	23¼
39	108	96	113¾	125¾	24¾	58	81	25¼
42	120	102	123¾	135¾	26	64	87	27
45	126	102	123¾	135¾	28	70	87	30
48	138	106	127⅞	139⅞	29¾	74	90	32⅞
51	144	110	133⅞	145⅞	31¾	78	96	34¾
54	150	118	143⅞	155⅞	33	80	102	37⅛
57	156	118	143⅞	155⅞	52	82	102	39⅛
60	162	125	150	162	54	88	108	40½
63	174	130	163	175	55½	92	114	42
66	180	150	175	187	57¼	96	132	44
69	186	156	180	194	60	100	136	45
72	192	160	186	200	63	102	141	46

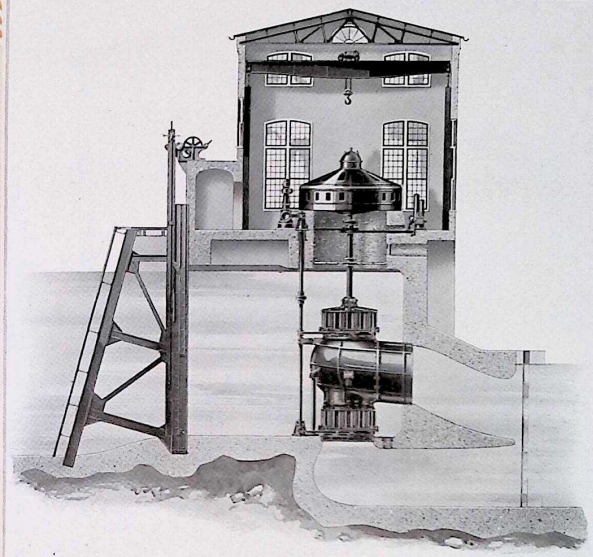
We make a specialty of building steel flumes to replace those made of wood. Owing to the decrease of flowage in the streams due to the reduction in forest area, it is necessay for the water power owner or user to save all the water possible, and he must not only have an efficient turbine, but his flume and water ways must be free from leakage. Wood flumes when first built may be free from leakage, but in a few years, if not inspected and repaired, soon leak and it is not always convenient to take the water out of the flume to repair it, consequently the leakage increases. The best way to overcome this is to use a steel flume. Flumes ten feet diameter and larger are "knocked down" before shipment.



Engraving No. 267

Represents a pair of Vertical Shaft Turbines in open flume driving horizontal shaft and rope sheave by means of bevel mortise gears.

We have furnished turbine equipments with from one to eight turbines driving one horizontal shaft, arranged for direct connection to generators and with pulley and rope drives.



Engraving No. 268

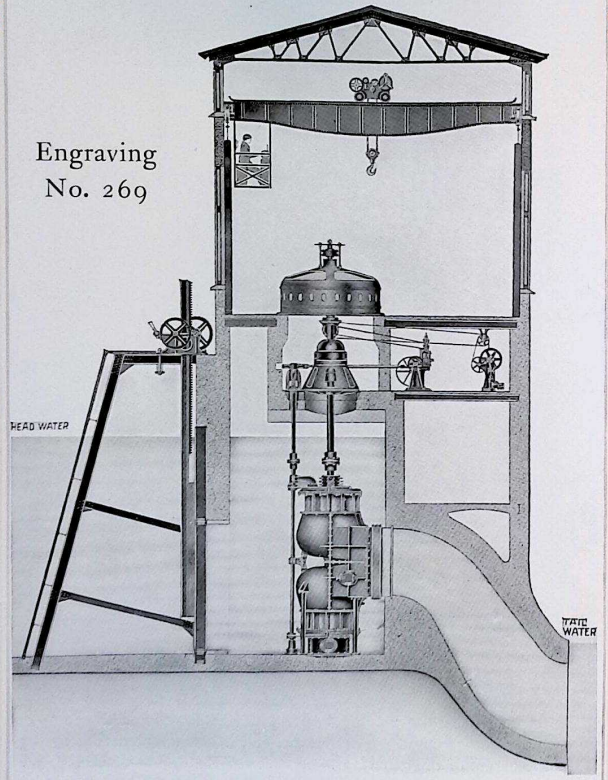
Represents a pair of "Smith" wicket gate turbines mounted on a vertical shaft, one above the other, and both discharging downward; the upper turbine through a cast iron elbow and a concrete draft tube, and the lower turbine into a concrete pit.

The thrust bearing for carrying the weight of the generator rotor, shaft, turbine runners and the downward thrust of same is mounted on top of the generator, and is usually furnished by the builders of the generator.

A cover plate of either cast iron or plate steel, and a packing box is usually placed between the turbines and the generator. A number of similar outfits are in daily operation and are giving entire satisfaction.

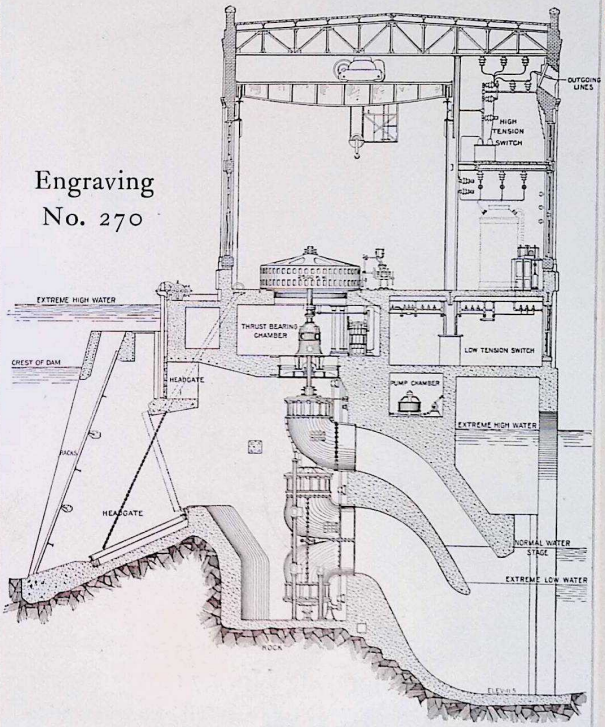
A pair of 72 "Smith" turbines are operating under 8 feet head.

Engraving
No. 269



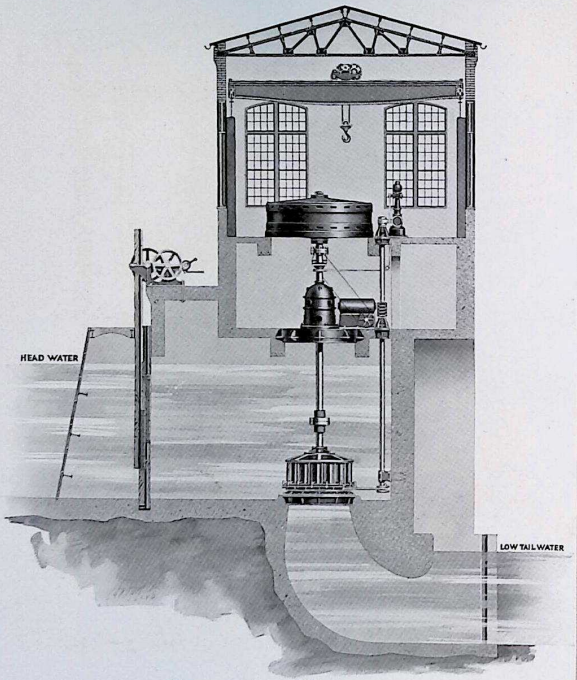
Pair Wicket Gate Turbines mounted on a vertical shaft, connected to an Umbrella Type Generator. Head 20 feet, 875 H.P., 150 R.P.M. Four pairs built for Milford Construction Co., Oldtown, Me. Also a pair of 400 H.P. to drive an exacter. Four pairs similarly mounted, built for Philadelphia Hydro Electric Co., Manayunk, Pa.

Engraving
No. 270



25,600 H.P. 133 R.P.M. Head varying from 24 to 34 feet. One of eight units of three wheels each, driving an Umbrella Type Generator in the plant of the Connecticut River Power Co., Vernon, Vt.

Also designed and built ten units of three wheels each for the Chattanooga & Tennessee River Power Co. Guild, Tenn., which were mounted in concrete flumes. Head varies from 20 to 39 ft. 42,000 H.P., 112½ R.P.M.

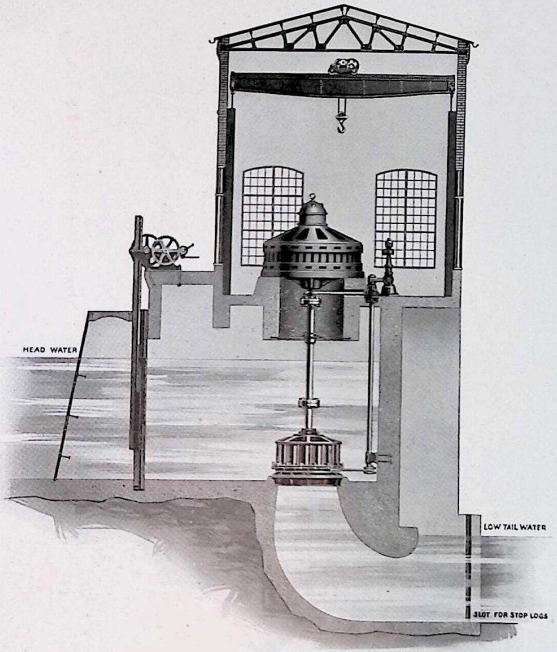


Engraving No. 271

Represents a "Smith" Wicket Gate Turbine arranged with concrete draft tube and for direct connection to a vertical generator. The thrust bearing is mounted on a heavy cast iron plate resting on a cast iron frame with an opening of sufficient size to permit the removal of the turbine. An I-beam frame can be used in place of cast iron if desired.

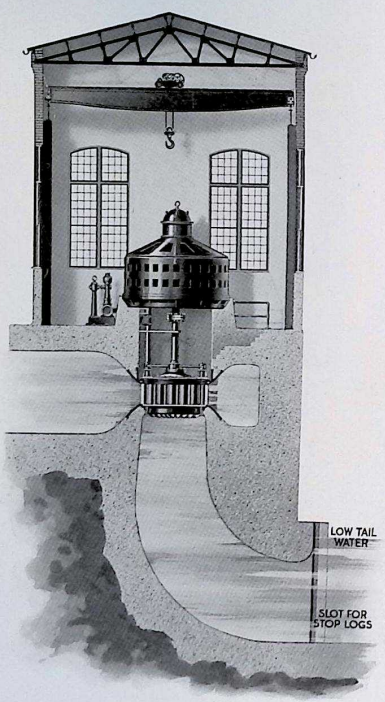
The governor, head gates and trash rack are also shown.

Both this type of setting and that shown on the opposite page are very popular. We are prepared to furnish all sizes of turbines arranged in this manner.



Engraving No. 272

Represents a "Smith" Wicket Gate Turbine arranged with a concrete draft tube and for direct connection to a vertical generator. The thrust bearing for carrying the weight and thrust of the runner, also, the weight of the rotor of the generator is placed on top of the generator instead of on a separate floor as shown by Engraving No. 269. By removing the rotor of the generator the turbine can be removed.

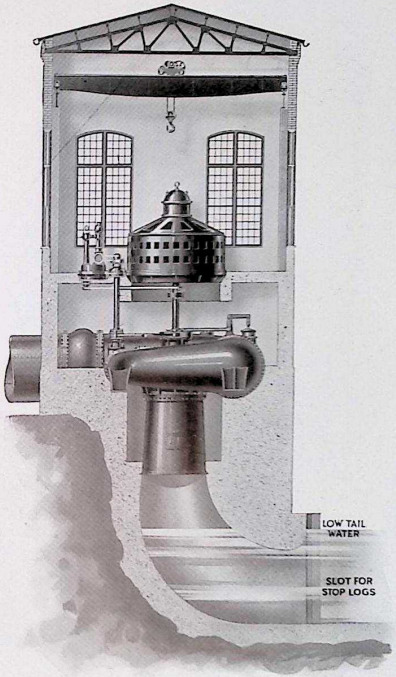


Engraving No. 273

Represents a Wicket Gate Turbine mounted in a concrete spiral flume and direct connected to a vertical generator.

The draft tube is of concrete. Flaring cast iron flanges with guide blades are imbedded in the concrete and act as a part of the concrete spiral flume.

The top plate of the turbine is provided with a bearing and packing box. The thrust bearing is mounted on top of the generator.



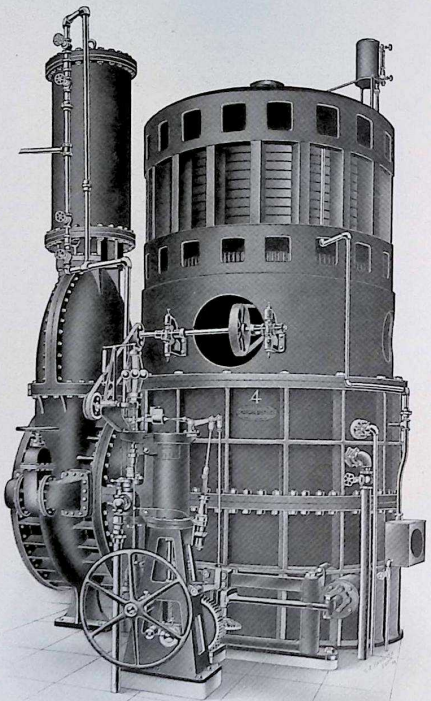
Engraving No. 274

Represents a Wicket Gate Turbine in a cast iron spiral flume direct connected to a vertical generator.

The upper section of the draft tube is steel, and the balance concrete.

A hydraulic gate valve, relief valve and governor are also shown. The thrust bearing is mounted on top of the generator.

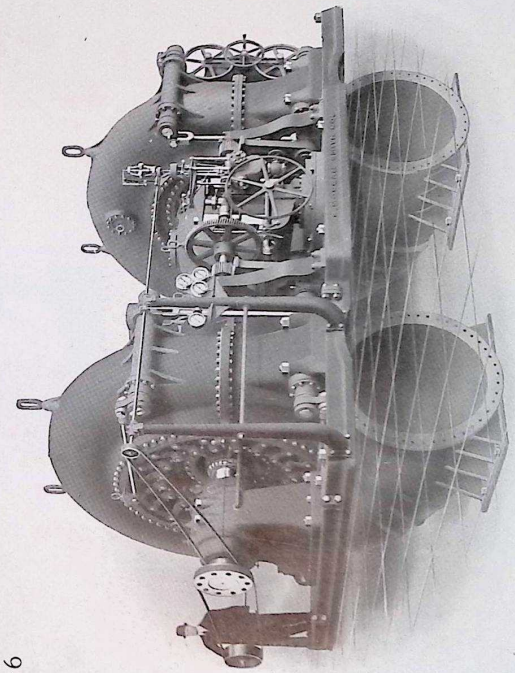
Five similar units, each of 17,000 H.P., 514 R.P.M. under 600 feet head were designed and built for the Georgia Power Company and installed in their Tallulah Falls Plant.



Engraving No. 275

9,000 H.P., 400 R.P.M., 226 feet head.

One of six Vertical Shaft Francis turbines in pressure flumes driving generators in the Roosevelt plant of the United States Government, Salt River, Ariz. We are prepared to build Francis turbines mounted in either spiral or pressure flumes of whatever power is required, within the limits of good engineering.



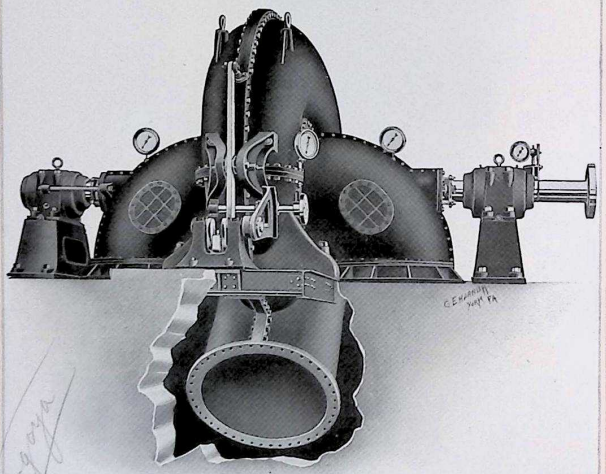
Engraving No. 276

Represents a Francis turbine unit consisting of two turbines, each mounted in a cast iron spiral flume discharging into one draft chest and draft tube. The gate operating mechanism is on the outside, the bronze runners and steel gates only being in the water.

Six units of 43,200 H.P., 225 R.P.M. under 100 feet head built for the Great Falls Water Power & Townsite Company, Great Falls, Mont.

These turbines when tested in place by the purchaser's engineer gave over 88 per cent. efficiency at 7-10 and 8-10 gate opening.

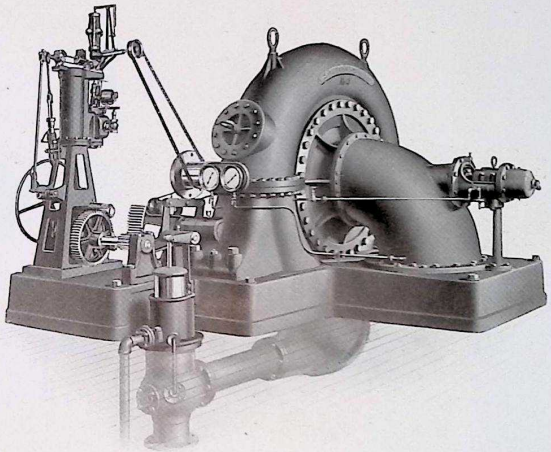
We are prepared to build turbines of this design to operate under heads 600 feet and lower.



Engraving No. 277

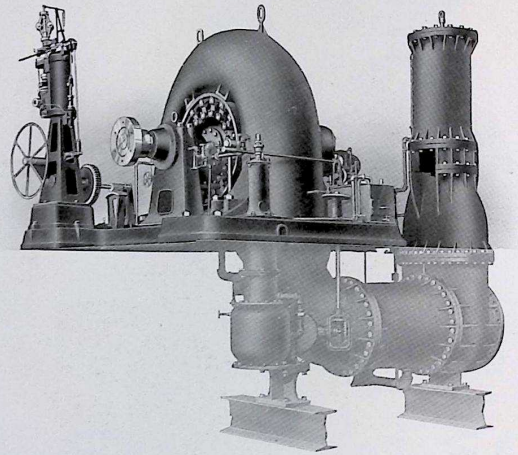
Represents a pair of Francis turbines in cast iron spiral flume arranged to connect direct to a generator. Four units developing 19,000 H.P., 360 R.P.M. under 150 feet head, built and installed in a plant in Japan.

We are prepared to build this style of turbine to operate under 600 feet head and lower.



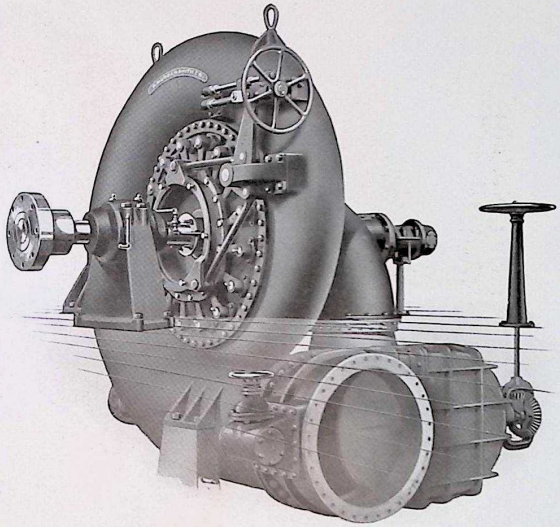
Engraving No. 278

Represents a single Francis turbine in a cast iron spiral flume with governor mounted on a bed plate. The relief valve is arranged to open when the governor closes the gates of the turbines suddenly, and then automatically closes. We are prepared to furnish similar settings to operate under heads up to 600 feet.



Engraving No. 279

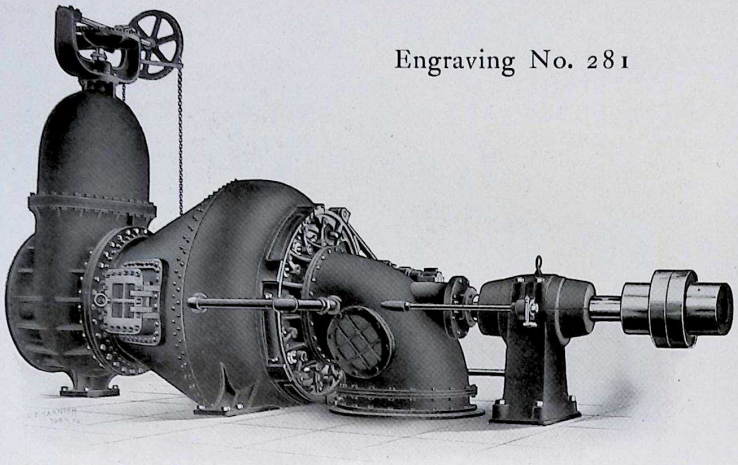
Represents a single Francis turbine in a cast iron spiral flume developing 1,700 H.P. at 720 R.P.M. under 280 feet head, mounted on a bed plate. The governor is of the oil pressure type. It opens the relief valve when the turbine gates are closed suddenly, and thus prevents an undue rise of pressure. Three of these outfits after having been installed, were tested and gave over 87 per cent. efficiency at 8-10 gate opening.



Engraving No. 280

Represents a single Francis turbine in a cast iron spiral flume developing 900 H.P. at 250 R.P.M. under 110 feet head arranged to drive two wood pulp grinders. It was mounted on the concrete floor of the mill. A similar setting can be mounted on I-beams or on a cast iron bed plate if desired. The gates are arranged for hand control but can be provided with connections to a governor if required.

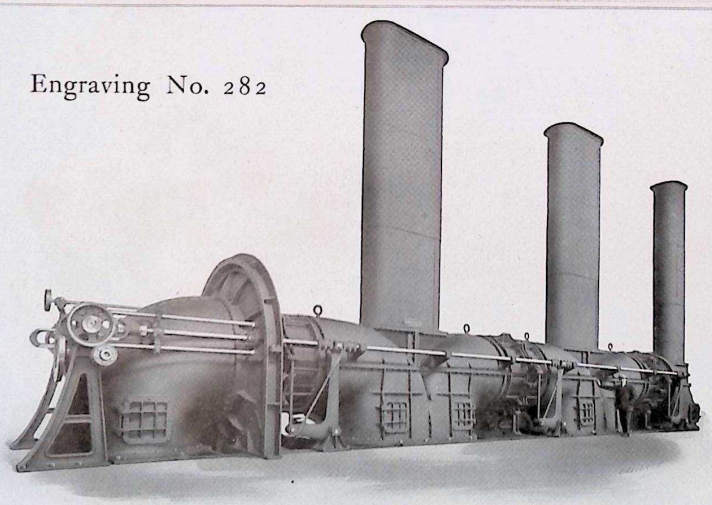
Engraving No. 281



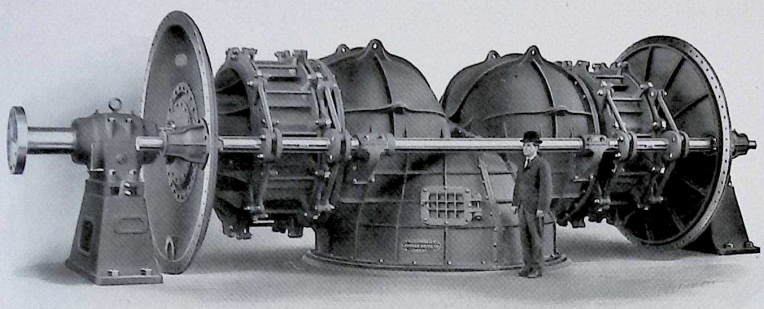
Single Francis turbine in pressure flume designed and built to develop 1200 H.P., at 514 R.P.M., under 190 feet head. The gate operating mechanism is outside the flume, the bronze runner and steel gates only being in the water.

We are prepared to design similar settings to meet requirements.

Engraving No. 282



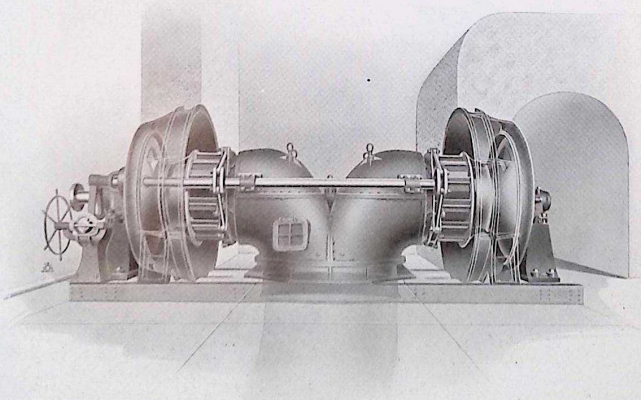
Sextuple Wicket Gate Turbine 6500 H.P., 164 R.P.M., 34 feet head. Two units are now operating generators in the Lockport plant of The Sanitary District of Chicago. The three inspection tubes arranged to pass through the top of the closed concrete flume, are provided with stairways leading to the oil bearings.



Engraving No. 283

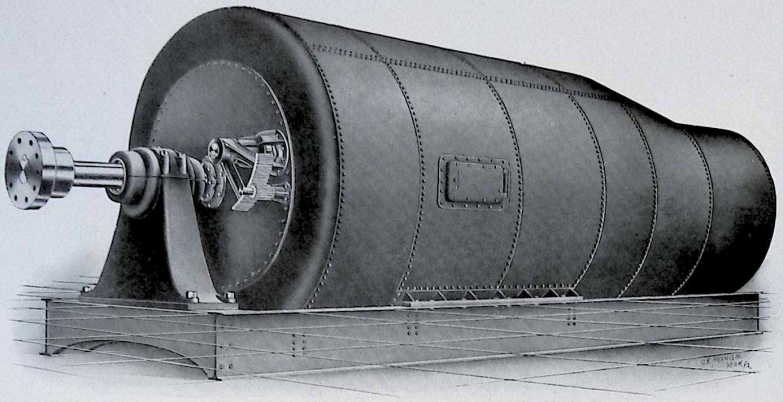
Pair Wicket Gate Turbines 5200 H.P., 225 R.P.M., 60 feet head. Six units with a total capacity of 31,200 H.P., each mounted in a steel flume, are now operating generators in a plant of the Southern Power Co., Charlotte, N. C.

We have built many hundreds of turbines mounted in the same way operating under almost every conceivable condition.



Engraving No. 284

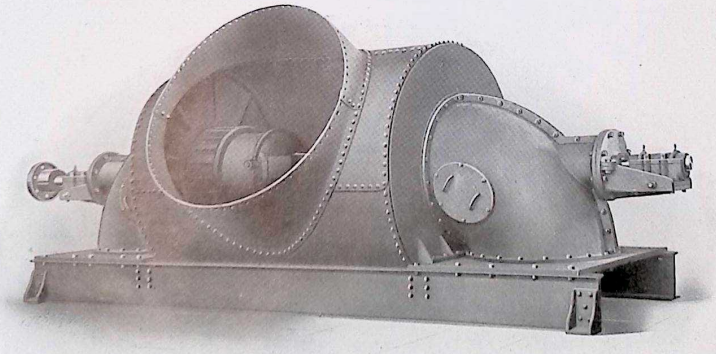
Represents one of six pairs of horizontal shaft turbines each having a capacity of 1800 H.P., at 200 R.P.M., under 42 feet head and mounted on a cast iron draft chest in an open flume with cast iron wall rings at each end extending through the concrete flume walls. The end bearings are of the ring oiling babbitted type. A tunnel is provided for access to the remote turbine and bearing.



Engraving No. 285

Represents a pair of Wicket Gate Turbines mounted on a cast iron draft chest in a steel flume with end supply.

We have built turbines mounted in this style which are developing several hundred thousand horse power.

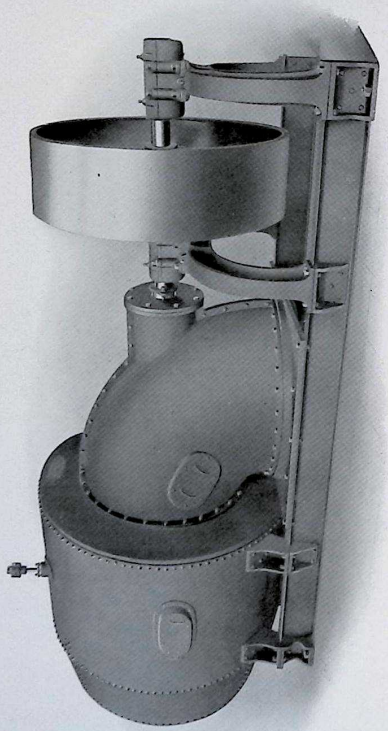


Engraving No. 286

Pair of cylinder gate turbines in steel flume discharging through two quarter-turns and draft tubes.

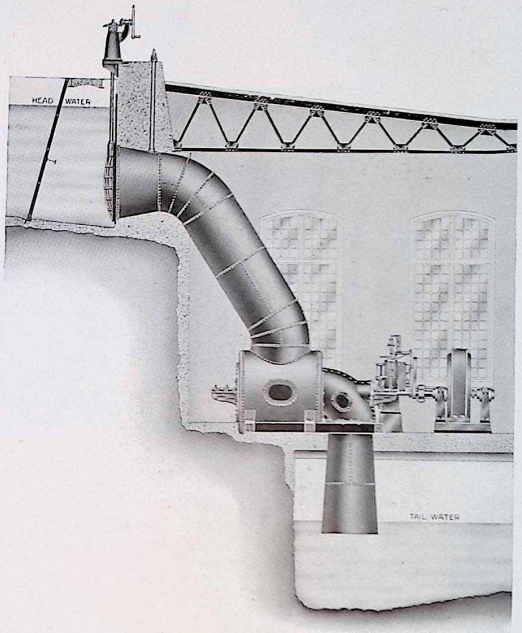
Outfits of this design can be arranged so that the gate of one of the turbines can be closed without entering the flume and only one turbine operated.

We build turbines with wicket gates similarly mounted.



Engraving No. 287

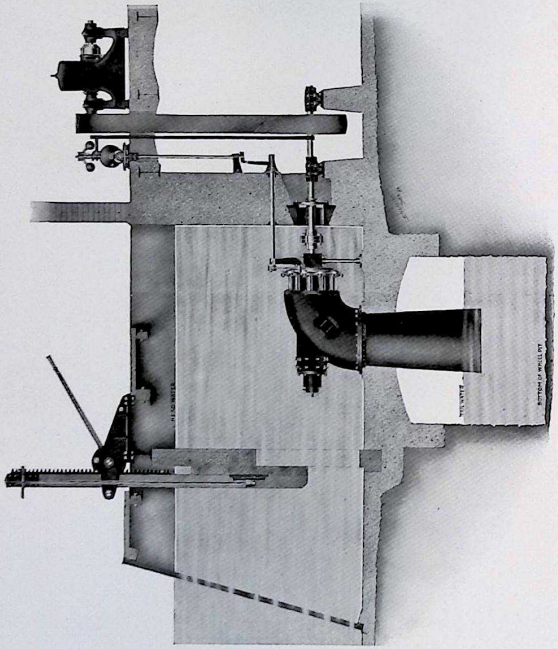
Single horizontal shaft turbine arranged to drive a generator by belt. The water enters through one end of the steel flume in which the turbine is mounted. We also build outfits arranged for direct connection to generators and pulp grinders by substituting a coupling for the pulley.



Engraving No. 288

Single turbine incased in steel flume with quarter-turn discharge. The water enters at the top of the flume.

We have built hundreds of turbines of similar design operating under many different conditions driving all kinds of machinery. We can place a pulley or rope sheave on the shaft instead of the coupling if desired.

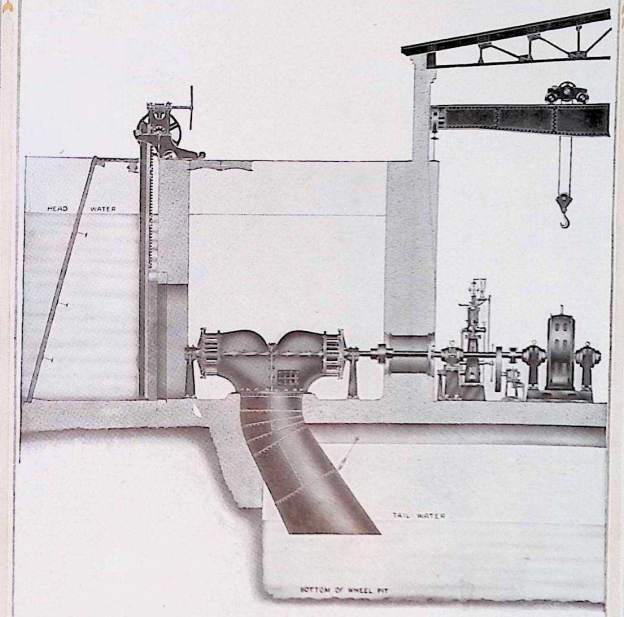


Engraving No. 289

"Smith" Wicket Gate Turbine in concrete flume driving generator.

This is a style of setting which is very popular with owners of small water powers.

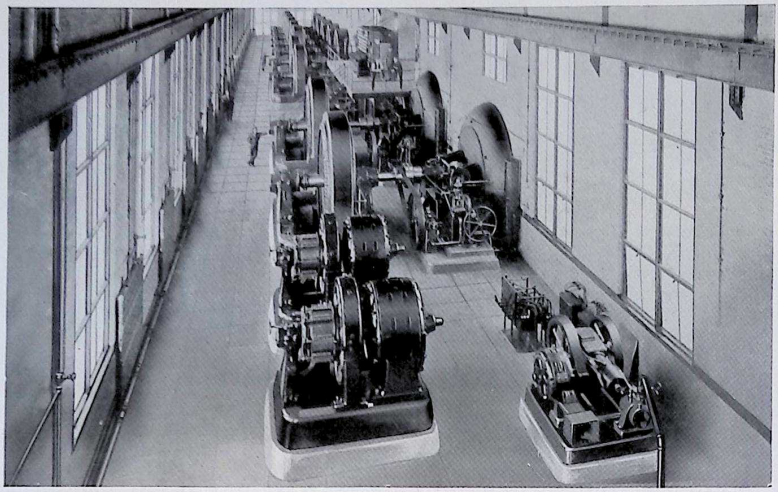
Many turbines mounted in this way are used throughout the world driving all kinds of machinery.



Engraving No. 290

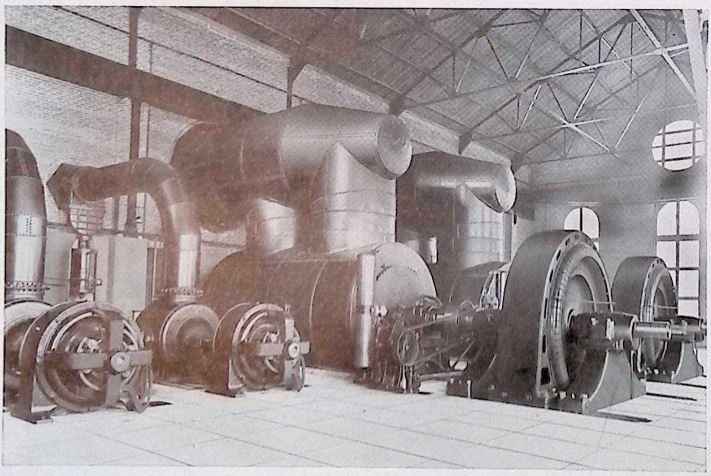
Pair Horizontal Shaft Wicket Gate Turbines mounted on a cast iron draft chest in an open flume, arranged to drive a generator. A pulley or rope sheave can be substituted for the coupling when desired.

We have built thousands of turbines with both cylinder and wicket gates similarly mounted which are driving generators, also machinery in pulp and paper mills.



Engraving No. 291

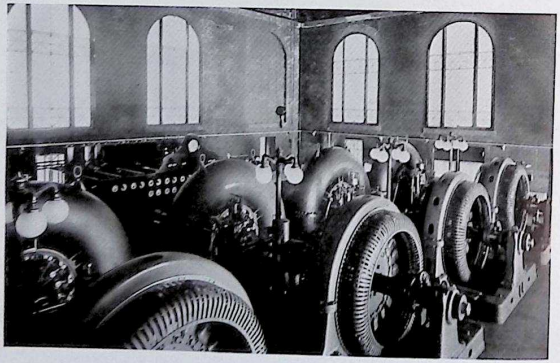
Power Plant of the Winnipeg Electric Railway Co., Winnipeg, Man. Nine quadruple units were built and installed in the above plant with a total capacity of 32,000 H.P. under 40 feet head.



Engraving No. 292

Power Plant of the La Crosse Water Power Co., La Crosse, Wis. Two turbine units each of 4000 H.P., 300 R.P.M. and two exciter units were installed in the above plant and are operating under 86 feet head.

Engraving No. 293



Engraving No. 294

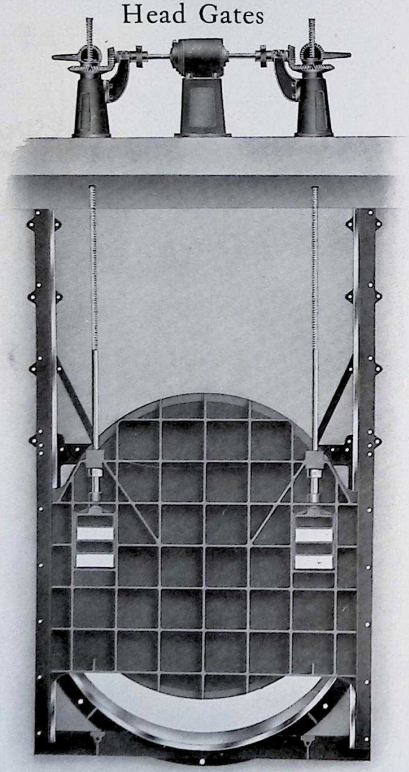
Represents the power house and dam of the Metropolitan Water & Sewerage Board, Clinton, Mass. (owned by the State of Massachusetts). Four Francis turbines in cast iron spiral flumes, each having a capacity of 1600 H.P., at 400 R.P.M. under 100 feet head have been in continuous operation several years.

Engraving No. 295

Engraving No. 296

Represents the exterior and interior of the power house of the Great Falls Water Power & Townsite Company, Great Falls, Mont., where six pairs of turbines are developing 43,200 H.P., 100 head. See page 35 for details.

Head Gates

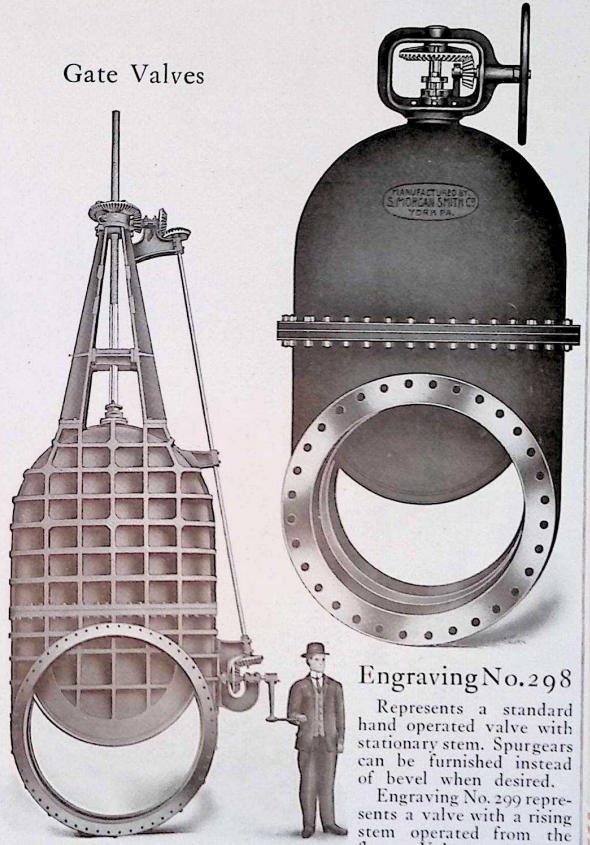


Engraving No. 297

Motor Operated Head Gates

Five of these iron gates, each covering an opening 10 feet diameter, were designed and built for the United States Reclamation Service for the Minadoka project. **We are prepared to furnish gates of all sizes and for any head.**

Gate Valves



Engraving No. 299

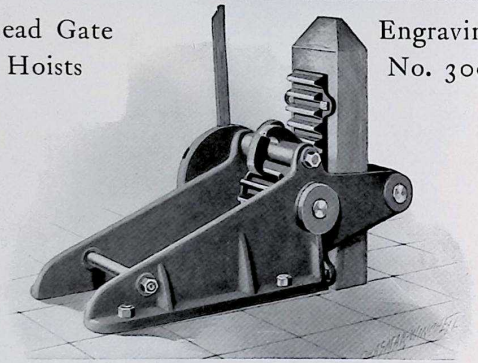
Engraving No. 298

Represents a standard hand operated valve with stationary stem. Spurgears can be furnished instead of bevel when desired.

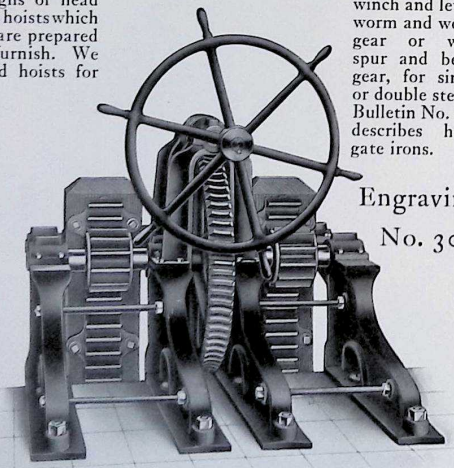
Engraving No. 299 represents a valve with a rising stem operated from the floor. Valves to operate under high heads are usually provided with by-passes.

Head Gate Hoists

Engraving No. 300



Two of many designs of head gate hoists which we are prepared to furnish. We build hoists for operation with winch and lever, worm and worm gear or with spur and bevel gear, for single or double stems. Bulletin No. 180 describes head gate irons.



Engraving No. 301

Measurement of Large Streams

In streams too large to measure by weir, the quantity of water is usually determined by "float measurement." In the use of this method it is important that the float be so made that it sinks well into the water. The measurements should be taken at a point where the velocity is not too great, and where the bed of the stream is uniform. If the stream be wide, the velocity in feet per minute should be taken near the shore and in the center; the average then is the velocity of the stream.

To ascertain the cubic feet of water, multiply the depth by the width, multiply this product by the velocity in feet per minute, and the result will be the number of cubic feet flowing per minute, from which deduct 20 per cent. for losses by friction, etc.

Measurement of Water Through Openings Under Pressure

Table giving the number of cubic feet of water discharged per minute, by an orifice one inch square, under any head from 3 to 62 inches.

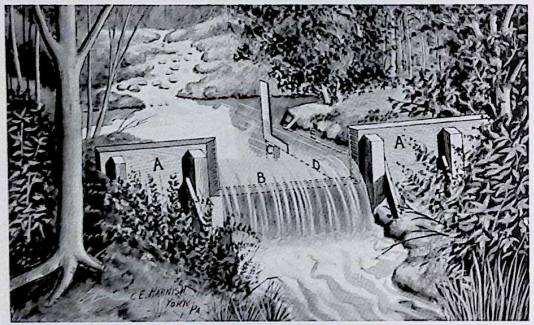
Head	Cubic Feet	Head	Cubic Feet	Head	Cubic Feet	Head	Cubic Feet	Head	Cubic Feet	Head	Cubic Feet
3	1.12	13	2.20	23	2.91	33	3.47	43	3.95	53	4.39
4	1.27	14	2.27	24	2.97	34	3.52	44	4.00	54	4.42
5	1.41	15	2.36	25	3.03	35	3.57	45	4.05	55	4.46
6	1.53	16	2.44	26	3.09	36	3.63	46	4.10	56	4.52
7	1.64	17	2.51	27	3.15	37	3.67	47	4.13	57	4.55
8	1.75	18	2.58	28	3.20	38	3.72	48	4.18	58	4.58
9	1.85	19	2.65	29	3.26	39	3.77	49	4.22	59	4.63
10	1.94	20	2.72	30	3.32	40	3.82	50	4.27	60	4.66
11	2.03	21	2.78	31	3.37	41	3.86	51	4.30	61	4.72
12	2.12	22	2.85	32	3.42	42	3.92	52	4.34	62	4.74

EXAMPLE, SHOWING APPLICATION OF ABOVE TABLE

Suppose the opening to let the water on an overshot wheel be 36 inches long and the gate hoisted 2 inches; the head of water above opening 25 inches. Multiply the length, 36, by 2 (the height the gate is hoisted) and the result will be 72, the number of square inches in opening.

By referring to the above table, opposite 25-inch head will be found 3.03; this multiplied by the 72 gives 218.16 the number of cubic feet of water passing through the opening per minute.

Rule for Measuring Water by Weirs



Engraving No. 302

When a water power is to be developed, the first thing to do is to measure the head and quantity of water in the stream. The following rule is generally used to ascertain the amount of water in a small stream.

Engraving No. 302 shows a weir. A is a board extending across stream with notch B, over which the water flows, beveled on down stream side. The stake at which measurements are taken is located 4 to 8 feet from weir, on up stream side, top being on a level with top notch in weir board as per line D. When the full flow of stream is passing over the weir the depth will be the distance from line D to line E (obtained by measuring on stake). The level of water surface on down stream side of weir should not be less than 8 inches below bottom of notch B in the weir board. The length of the notch B should never be less than three to four times the depth for very small streams, and longer for larger streams. See table for weir measurements on opposite page.

Table Showing the Quantity of Water Passing Over Weirs in Cubic Feet per Minute

Depth of water on weir in inch.	Cubic feet per minute passed for each foot of length of weir.	Depth of water on weir in inch.	Cubic feet per minute passed for each foot of length of weir.	Depth of water on weir in inch.	Cubic feet per minute passed for each foot of length of weir.	Depth of water on weir in inch.	Cubic feet per minute passed for each foot of length of weir.
1	4.85	4¾	50.20	8½	120.18	12½	214.32
1⅛	5.78	4⅞	52.18	8⅝	122.82	12¾	220.76
1¼	6.68	5	54.22	8¾	125.52	13	227.30
1⅜	7.80	5⅛	56.25	8⅞	128.14	13¼	233.92
1½	8.90	5¼	58.33	9	130.93	13½	240.54
1⅝	10.00	5⅜	60.42	9⅛	133.65	13¾	247.22
1¾	11.23	5½	62.55	9¼	136.43	14	254.03
1⅞	12.45	5⅝	64.68	9⅜	139.18	14¼	260.83
2	13.72	5¾	66.86	9½	141.99	14½	267.77
2⅛	15.02	5⅞	68.98	9⅝	144.80	14¾	274.70
2¼	16.36	6	71.27	9¾	147.64	15	281.72
2⅜	17.75	6⅛	73.45	9⅞	150.47	15¼	288.82
2½	19.17	6¼	75.77	10	153.35	15½	295.93
2⅝	20.63	6⅜	78.04	10⅛	156.20	15¾	303.10
2¾	22.11	6½	80.36	10¼	159.14	16	310.36
2⅞	23.63	6⅝	82.63	10⅜	162.07	16¼	317.69
3	25.20	6¾	85.04	10½	164.99	16½	325.03
3⅛	26.78	6⅞	87.43	10⅝	167.89	16¾	332.42
3¼	28.43	7	89.82	10¾	169.92	17	339.91
3⅜	30.06	7⅛	92.16	10⅞	173.90	17¼	347.45
3½	31.75	7¼	94.67	11	176.92	17½	355.02
3⅝	33.45	7⅜	97.11	11⅛	179.94	17¾	362.77
3¾	35.22	7½	99.50	11¼	182.99	18	370.34
3⅞	36.98	7⅝	102.10	11⅜	186.03	18¼	378.12
4	38.80	7¾	104.63	11½	189.13	18½	385.87
4⅛	40.63	7⅞	107.13	11⅝	192.20	18¾	393.66
4¼	42.49	8	109.74	11¾	195.32	19	401.63
4⅜	44.39	8⅛	112.31	11⅞	198.47	19¼	409.58
4½	46.29	8¼	114.91	12	201.59	19½	417.48
4⅝	48.22	8⅜	117.51	12¼	207.94	19¾	425.68

For explanation of above table and construction of Weirs see opposite page.

Velocity of Water

Table giving velocity of water in feet per second, and the cubic feet of water per minute, to develop one horse-power at 80 per cent. efficiency under heads from 1 to 297 feet.

Head	Velocity	Cubic Feet	Head	Velocity	Cubic Feet	Head	Velocity	Cubic Feet
1	8.02	661.765	49	56.14	13.505	97	79.00	6.822
2	11.34	330.883	50	56.71	13.236	98	79.40	6.753
3	13.89	220.589	51	57.27	12.976	99	79.81	6.685
4	16.04	165.441	52	57.84	12.726	100	80.22	6.618
5	17.92	132.353	53	58.39	12.486	101	80.61	6.552
6	19.65	110.294	54	58.93	12.255	102	81.01	6.487
7	21.22	94.538	55	59.48	12.032	103	81.40	6.425
8	22.68	82.720	56	60.01	11.817	104	81.80	6.363
9	24.06	73.529	57	60.56	11.610	105	82.19	6.303
10	25.36	66.177	58	61.08	11.410	106	82.58	6.243
11	26.60	60.160	59	61.61	11.216	107	82.97	6.185
12	27.78	55.147	60	62.12	11.029	108	83.35	6.127
13	28.92	50.905	61	62.71	10.849	109	83.74	6.071
14	30.01	47.269	62	63.15	10.674	110	84.12	6.016
15	31.06	44.118	63	63.66	10.504	111	84.50	5.962
16	32.08	41.360	64	64.16	10.340	112	84.88	5.909
17	33.07	38.927	65	64.66	10.181	113	85.25	5.857
18	34.03	36.765	66	65.16	10.027	114	85.63	5.805
19	34.96	34.830	67	65.65	9.877	115	86.00	5.755
20	35.87	33.088	68	66.14	9.732	116	86.38	5.705
21	36.75	31.513	69	66.62	9.591	117	86.75	5.656
22	37.61	30.080	70	67.11	9.454	118	87.12	5.608
23	38.46	28.772	71	67.58	9.321	119	87.49	5.561
24	39.29	27.574	72	68.06	9.191	120	87.86	5.514
25	40.10	26.471	73	68.53	9.065	121	88.22	5.469
26	40.89	25.453	74	69.00	8.943	122	88.58	5.424
27	41.67	24.510	75	69.46	8.822	123	88.94	5.380
28	42.44	23.634	76	69.92	8.707	124	89.30	5.337
29	43.19	22.819	77	70.38	8.594	125	89.66	5.294
30	43.93	22.059	78	70.84	8.484	126	90.02	5.252
31	44.65	21.347	79	71.29	8.377	127	90.38	5.211
32	45.37	20.680	80	71.74	8.272	128	90.74	5.170
33	46.07	20.053	81	72.19	8.170	129	91.09	5.130
34	46.77	19.464	82	72.63	8.070	130	91.44	5.090
35	47.45	18.908	83	73.07	7.973	131	91.79	5.051
36	48.12	18.382	84	73.51	7.878	132	92.14	5.013
37	48.78	17.886	85	73.95	7.785	133	92.49	4.976
38	49.44	17.415	86	74.38	7.695	134	92.84	4.939
39	50.09	16.968	87	74.81	7.606	135	93.19	4.902
40	50.72	16.544	88	75.24	7.520	136	93.54	4.866
41	51.35	16.141	89	75.67	7.436	137	93.88	4.830
42	51.98	15.756	90	76.09	7.353	138	94.22	4.795
43	52.59	15.390	91	76.51	7.272	139	94.56	4.761
44	53.20	15.040	92	76.93	7.193	140	94.90	4.727
45	53.80	14.706	93	77.35	7.116	141	95.23	4.693
46	54.40	14.368	94	77.76	7.040	142	95.57	4.660
47	54.99	14.080	95	78.18	6.966	143	95.90	4.627
48	55.57	13.787	96	78.59	6.893	144	96.24	4.595

Velocity of Water—(Continued)

Head	Velocity	Cubic Feet	Head	Velocity	Cubic Feet	Head	Velocity	Cubic Feet
145	96.57	4.563	196	112.28	3.376	247	126.05	2.679
146	96.90	4.532	197	112.57	3.359	248	126.30	2.668
147	97.23	4.501	198	112.85	3.342	249	126.56	2.657
148	97.56	4.471	199	113.14	3.325	250	126.81	2.647
149	97.89	4.441	200	113.42	3.309	251	127.07	2.636
150	98.22	4.411	201	113.70	3.292	252	127.32	2.626
151	98.53	4.382	202	113.98	3.276	253	127.57	2.616
152	98.88	4.353	203	114.26	3.259	254	127.82	2.605
153	99.20	4.325	204	114.54	3.243	255	128.07	2.595
154	99.53	4.297	205	114.82	3.227	256	128.32	2.585
155	99.85	4.269	206	115.11	3.212	257	128.57	2.575
156	100.18	4.242	207	115.39	3.196	258	128.82	2.565
157	100.50	4.215	208	115.68	3.181	259	129.07	2.555
158	100.81	4.188	209	115.95	3.166	260	129.32	2.545
159	101.13	4.162	210	116.23	3.151	261	129.57	2.535
160	101.44	4.136	211	116.50	3.136	262	129.82	2.525
161	101.75	4.110	212	116.78	3.121	263	130.07	2.515
162	102.07	4.085	213	117.05	3.106	264	130.32	2.506
163	102.38	4.060	214	117.32	3.092	265	130.57	2.497
164	102.70	4.035	215	117.59	3.077	266	130.81	2.488
165	103.01	4.010	216	117.86	3.063	267	131.06	2.478
166	103.33	3.986	217	118.13	3.049	268	131.30	2.469
167	103.64	3.962	218	118.41	3.035	269	131.55	2.460
168	103.96	3.939	219	118.68	3.021	270	131.79	2.451
169	104.27	3.915	220	118.96	3.008	271	132.04	2.442
170	104.57	3.892	221	119.22	2.994	272	132.28	2.433
171	104.88	3.869	222	119.49	2.981	273	132.52	2.424
172	105.18	3.847	223	119.75	2.967	274	132.76	2.415
173	105.49	3.825	224	120.02	2.954	275	133.00	2.406
174	105.79	3.803	225	120.30	2.941	276	133.24	2.397
175	106.10	3.781	226	120.57	2.928	277	133.49	2.388
176	106.40	3.760	227	120.85	2.915	278	133.73	2.380
177	106.70	3.739	228	121.12	2.902	279	133.98	2.371
178	107.00	3.718	229	121.38	2.889	280	134.22	2.363
179	107.30	3.697	230	121.64	2.877	281	134.46	2.354
180	107.60	3.676	231	121.90	2.864	282	134.70	2.346
181	107.90	3.656	232	122.16	2.852	283	134.94	2.338
182	108.20	3.636	233	122.42	2.840	284	135.16	2.330
183	108.50	3.616	234	122.69	2.828	285	135.40	2.321
184	108.80	3.596	235	122.95	2.816	286	135.64	2.313
185	109.09	3.577	236	123.22	2.804	287	135.88	2.305
186	109.39	3.558	237	123.47	2.792	288	136.12	2.297
187	109.68	3.539	238	123.73	2.780	289	136.36	2.289
188	109.98	3.520	239	123.98	2.768	290	136.60	2.281
189	110.27	3.501	240	124.24	2.757	291	136.84	2.273
190	110.56	3.483	241	124.50	2.745	292	137.06	2.266
191	110.85	3.464	242	124.76	2.734	293	137.29	2.258
192	111.14	3.446	243	125.02	2.723	294	137.53	2.250
193	111.42	3.429	244	125.28	2.712	295	137.76	2.242
194	111.71	3.411	245	125.54	2.701	296	138.00	2.235
195	111.99	3.393	246	125.79	2.690	297	138.23	2.227

S. MORGAN SMITH COMPANY

Areas and Circumferences of Circles in Feet

Diameter Ft.	Diameter In.	Area Square ft.	Circumference Ft.	Circumference In.
1		.7854	3	1⅝
	1	.9217	3	4⅝
	2	1.0690	3	8
	3	1.2271	3	11
	4	1.3962	4	2⅜
	5	1.5761	4	5⅜
	6	1.7671	4	8¼
	7	1.9689	4	11⅝
	8	2.1816	5	2⅜
	9	2.4052	5	5⅞
	10	2.6398	5	9
	11	2.8852	6	2¼
2		3.1416	6	3⅜
	1	3.4087	6	6½
	2	3.6869	6	9⅝
	3	3.976	7	¾
	4	4.276	7	3⅞
	5	4.5869	7	7
	6	4.9087	7	10¼
	7	5.2413	8	⅜
	8	5.585	8	1⅜
	9	5.9395	8	4½
	10	6.3049	8	7⅝
	11	6.6813	8	10¾
3		7.0686	9	1⅞
	1	7.4666	9	5
	2	7.8757	9	8¼
	3	8.2957	9	11⅜
	4	8.7265	10	2½
	5	9.1683	10	5⅝
	6	9.6211	10	8¾
	7	10.0846	10	11⅞
	8	10.5591	11	3
	9	11.0446	11	6⅛
	10	11.5409	11	9⅜
	11	12.0481	12	½
4		12.5664	12	3⅝
	1	13.0952	12	6¾
	2	13.6343	12	9⅞
	3	14.1862	13	1
	4	14.7479	13	4⅛
	5	15.3206	13	7¼
	6	15.9043	13	10⅜
	7	16.4986	14	1⅝
	8	17.1041	14	4⅝
	9	17.7205	14	7¾
	10	18.3476	14	11
	11	18.9858	15	2⅜
5		19.635	15	5½
	1	20.2947	15	8⅝
	2	20.9656	15	11⅞
	3	21.6475	16	2¾
	4	22.34	16	5¾
	5	23.0437	16	9
	6	23.7583	16	3⅛
	7	24.4835	17	6⅜
	8	25.2199	17	9⅝
	9	25.9672	17	¾
	10	26.7251	17	3⅞
	11	27.4943	18	7⅛
6		28.2744	18	10⅜
	1	29.0649	19	1¼
	2	29.8668	19	4⅜
	3	30.6796	19	7½
	4	31.5029	19	10⅝
	5	32.3376	20	1⅞
	6	33.1831	20	4⅞
	7	34.0391	20	8⅛
	8	34.9065	20	11½
	9	35.7847	21	2⅜
	10	36.6735	21	5½
	11	37.5736	21	8¾
7		38.4846	21	11⅞
	1	39.406	22	3
	2	40.3388	22	6⅛
	3	41.2825	22	9¼
	4	42.2367	23	⅜
	5	43.2022	23	3¼
	6	44.1787	23	6⅞
	7	45.1656	23	9¾
	8	46.1638	24	1⅛
	9	47.173	24	4⅜
	10	48.1926	24	7½
	11	49.2236	24	10⅝
8		50.2656	25	1½
	1	51.3178	25	4⅝
	2	52.3816	25	7⅞
	3	53.4562	25	11
	4	54.5412	26	2⅛
	5	55.6377	26	5¼
	6	56.7451	26	8⅜
	7	57.8628	26	11½
	8	58.992	27	2¾
	9	60.1321	27	5¾
	10	61.2826	27	9
	11	62.4445	28	⅛
9		63.6174	28	3¼
	1	64.8006	28	6⅜
	2	65.9951	28	9½
	3	67.2007	29	⅝
	4	68.4166	29	3¾
	5	69.644	29	7
	6	70.8823	29	10⅛
	7	72.1309	30	1¾
	8	73.391	30	4⅞
	9	74.662	30	7½
	10	75.9433	30	11⅝
	11	77.2362	31	1¾
10		78.54	31	5
	1	79.854	31	8⅛
	2	81.1795	31	11¼
	3	82.516	32	2⅜
	4	83.8627	32	5½
	5	85.2211	32	8⅝
	6	86.5903	32	11¾
	7	87.9697	33	2⅞
	8	89.3608	33	6⅛
	9	90.7627	33	9¼
	10	92.1749	34	⅜
	11	93.5986	34	3½
11		95.0334	34	6⅝
	1	96.4783	34	9¾
	2	97.9347	35	⅞
	3	99.4021	35	4⅛
	4	100.8797	35	7¼
	5	102.3689	35	10⅝
	6	103.8691	36	1½
	7	105.3794	36	4½
	8	106.9013	36	7¾
	9	108.4342	36	10⅜
	10	109.9772	37	2¼
	11	111.5319	37	5¼
12		113.0976	37	8¾
	1	114.6732	37	11½
	2	116.2607	38	2⅝
	3	117.859	38	5¼
	4	119.4674	38	8⅞
	5	121.0876	39	
	6	122.7187	39	3¼
	7	124.3598	39	6⅜
	8	126.0127	39	9½
	9	127.6756	40	⅝
	10	129.3504	40	3¾
	11	131.036	40	6⅞
13		132.7326	40	10
	1	134.4391	41	1⅜
	2	136.1574	41	4⅜
	3	137.8867	41	7½
	4	139.626	41	10⅝
	5	141.3771	42	1⅜
	6	143.1391	42	4⅞
	7	144.9111	42	8
	8	146.6949	42	11⅛
	9	148.4896	43	2¼
	10	150.2943	43	5½
	11	152.1109	43	8⅝
14		153.9384	43	11¾
	1	155.7758	44	2⅞
	2	157.625	44	6
	3	159.4852	44	9⅛
	4	161.3553	44	¼
	5	163.2373	45	3½
	6	165.1303	45	6⅝
	7	167.0331	45	9¾
	8	168.9479	46	⅞
	9	170.8735	46	4
	10	172.8091	46	7⅛
	11	174.7565	46	11¼
15		176.715	47	1½
	1	178.6832	47	4⅝
	2	180.6634	47	7¾
	3	182.6545	47	10½
	4	184.6555	48	2½
	5	186.6684	48	5⅜
	6	188.6923	48	8¼
	7	190.726	48	11⅜
	8	192.7716	49	2⅝
	9	194.8282	49	5¾
	10	196.8946	49	8⅞
	11	198.973	50	
16		201.0624	50	3⅛
	1	203.1615	50	6¼
	2	205.2726	50	9⅜
	3	207.3946	51	½
	4	209.5264	51	3¾
	5	211.6703	51	6½
	6	213.8251	51	10
	7	215.9896	52	1⅜
	8	218.1662	52	4¼
	9	220.3537	52	7⅜
	10	222.551	52	10½
	11	224.7603	53	1⅝
17		226.9806	53	4⅞
	1	229.2105	53	8
	2	231.4525	53	11⅛
	3	233.7055	54	2⅛
	4	235.9682	54	5⅜
	5	238.243	54	8½
	6	240.5287	54	11⅝
	7	242.8241	55	2⅞
	8	245.1316	55	6
	9	247.45	55	9⅜
	10	249.7781	56	¾
	11	252.1184	56	3⅝
18		254.4696	56	6½
	1	256.8303	56	9⅝
	2	259.2033	57	⅞
	3	261.5872	57	4
	4	263.9807	57	7⅛
	5	266.3864	57	10¼
	6	268.8031	58	1⅜
	7	271.2293	58	4½
	8	273.6678	58	7⅝
	9	276.1171	58	10¾
	10	278.5761	59	2
	11	281.0472	59	5⅜
19		283.5294	59	8¼
	1	286.021	59	11½
	2	288.5249	60	2½
	3	291.0397	60	5⅝
	4	293.5641	60	8¾
	5	296.1107	60	11⅞
	6	298.6483	61	3⅛
	7	301.2054	61	6¼
	8	303.7747	61	9½
	9	306.355	62	½
	10	308.9448	62	3⅝
	11	311.5469	62	6¾
20		314.16	62	9⅞
	1	316.7824	63	1⅛
	2	319.4173	63	4½
	3	322.063	63	7⅞
	4	324.7182	63	11½
	5	327.3858	64	1⅝
	6	330.0643	64	4¾
	7	332.7522	64	7⅞
	8	335.4525	64	11
	9	338.1637	65	2¼
	10	340.8844	65	5⅝
	11	343.6174	65	8¾
21		346.3614	65	11⅝
	1	349.1147	66	2¾
	2	351.8804	66	5⅞
	3	354.6571	66	9
	4	357.4432	67	⅛
	5	360.2417	67	3⅜
	6	363.0511	67	6½
	7	365.8698	67	9⅝
	8	368.7011	68	¾
	9	371.5432	68	3⅞
	10	374.3947	68	7
	11	377.2587	68	10¼
22		380.1336	69	1⅜
	1	383.0177	69	4½
	2	385.9144	69	7⅝
	3	388.822	69	10¾
	4	391.7389	70	1⅞
	5	394.6683	70	5
	6	397.6087	70	8¼
	7	400.5583	70	11⅛
	8	403.5204	71	2½
	9	406.4935	71	5⅝
	10	409.4759	71	8¾
	11	412.4707	71	11⅞
23		415.4766	72	3
	1	418.4915	72	6⅛
	2	421.5192	72	9⅜
	3	424.5577	73	½
	4	427.6055	73	3⅝
	5	430.6658	73	6¾
	6	433.7371	73	9⅞
	7	436.8175	74	1
	8	439.9106	74	4⅛
	9	443.0146	74	7¼
	10	446.1278	74	10⅝
	11	449.2536	75	1⅝
24		452.3904	75	4¾
	1	455.5362	75	7⅞
	2	458.6948	75	11
	3	461.8641	76	2⅜
	4	465.0428	76	5¼
	5	468.2341	76	8½
	6	471.4363	76	11⅝
	7	474.6476	77	2¾
	8	477.8716	77	5⅞
	9	481.1065	77	9
	10	484.3506	78	⅛
	11	487.6073	78	3¼
25		490.875	78	6½
	1	494.1516	78	9½
	2	497.4411	79	¾
	3	500.7415	79	3⅞
	4	504.051	79	7⅛
	5	507.3732	79	11⅛
	6	510.7063	80	1¼
	7	514.0484	80	4⅜
	8	517.4034	80	7⅝
	9	520.7692	80	10¾
	10	524.1441	81	1⅞
	11	527.5318	81	5

S. MORGAN SMITH COMPANY

Areas and Circumferences of Circles in Feet

Loss in head in each 100 feet length of pipe at different velocities

Vel. in Feet Per Second	Head Required to Produce Vel.	Head Required to Overcome Loss at Ent. of Pipe	FRICTION HEAD IN FEET FOR PIPES 100 FEET LONG FROM 1.00 TO 5.00 FT. DIA. INCLUSIVE WITH CUBIC FEET DISCHARGE PER MINUTE UNDER VELOCITIES FROM 1.0 TO 12.0 FT. INCLUSIVE PER SECOND.															
			1.00 Dia.		1.50 Dia.		2.00 Dia.		2.50 Dia.		3.00 Dia.		3.50 Dia.		4.00 Dia.		4.50 Dia.		5.00 Dia.	
			Friction Head	Cubic Feet	Friction Head	Cubic Feet	Friction Head	Cubic Feet	Friction Head	Cubic Feet	Friction Head	Cubic Feet	Friction Head	Cubic Feet	Friction Head	Cubic Feet	Friction Head	Cubic Feet	Friction Head	Cubic Feet
1.0	.01552	.00776	.048	47.	.031	106.	.024	188.	.019	295.	.015	424	..	577.	..	754.	..	954.	..	1178
1.2	.02236	.01118	.067	56.	.044	127.	.033	226.	.026	353.	.022	509	.019	693.	.016	905.	.014	1145.	.013	1414
1.4	.03043	.01521	.087	66.	.057	148.	.043	264.	.034	412.	.029	594.	.024	808.	.021	1056.	.019	1336.	.017	1649
1.6	.03975	.01987	.111	75.	.073	170.	.055	302.	.044	471.	.036	679	.031	924	.027	1206.	.024	1527.	.022	1885
1.8	.05031	.02515	.136	85.	.090	191.	.068	339.	.054	530.	.045	763.	.038	1039.	.034	1357.	.030	1718.	.027	2120.
2.0	.06211	.03105	.164	94.	.109	212.	.082	377.	.065	589.	.054	848.	.046	1155.	.041	1508.	.036	1908.	.032	2356.
2.2	.07515	.03787	.195	104.	.129	233.	.097	415.	.078	648.	.064	933.	.055	1270	.048	1659.	.043	2099.	.039	2592.
2.4	.08944	.04472	.227	113.	.151	254.	.113	452.	.090	707.	.075	1018.	.064	1385.	.057	1810	.050	2290.	.045	2827.
2.6	.10496	.05248	.262	123.	.174	276.	.131	490.	.104	766.	.087	1103.	.074	1501.	.065	1960.	.058	2481.	.052	3063.
2.8	.12173	.06086	.300	132.	.199	297.	.150	528.	.120	825.	.099	1188.	.085	1616.	.075	2111.	.066	2672.	.060	3299
3.0	.13975	.06987	.339	141.	.225	318.	.169	565.	.135	884.	.112	1272.	.096	1732.	.084	2262.	.075	2863.	.067	3534.
3.2	.159	.0795	.381	151.	.263	339.	.190	603.	.152	942.	.126	1357	.108	1847.	.095	2413.	.084	3054.	.076	3770.
3.4	.1795	.08975	.425	160.	.283	360.	.212	641.	.170	1001.	.141	1442.	.121	1963.	.106	2563.	.094	3244.	.085	4006.
3.6	.20124	.10062	.471	170.	.313	382.	.235	679.	.188	1060.	.156	1527.	.134	2078.	.117	2714.	.104	3435.	.094	4241.
3.8	.22422	.11211	.520	179.	.346	403.	.260	716.	.208	1119.	.173	1612.	.148	2194.	.130	2865.	.115	3626.	.104	4477.
4.0	.24844	.12422	.570	188.	.379	424.	.285	754.	.228	1178.	.189	1697.	.162	2309.	.142	3016.	.126	3817.	.114	4712.
4.2	.27391	.13695	.623	198.	.415	445.	.311	791.	.249	1237.	.207	1781.	.177	2425.	.155	3167.	.138	4008.	.124	4948.
4.4	.30062	.15031	.678	207.	.452	467.	.339	829.	.271	1296.	.226	1866.	.193	2540.	.169	3317.	.150	4199.	.135	5184.
4.6	.32888	.16444	.736	217.	.490	488.	.368	867.	.294	1355.	.245	1951.	.210	2655.	.184	3468.	.163	4390.	.147	5419.
4.8	.35776	.17888	.795	226.	.529	509.	.397	905.	.318	1414.	.264	2036.	.227	2771.	.198	3619.	.176	4580.	.159	5655.
5.0	.38819	.19409	.856	236.	.570	530.	.428	942.	.342	1473.	.285	2121.	.244	2886.	.214	3770.	.190	4771.	.171	5891.
5.2	.41987	.20993	.920	245.	.613	551.	.46	980.	.368	1532.	.306	2205.	.262	3002.	.230	3921.	.204	4962.	.184	6126.
5.4	.45279	.22639	.986	254.	.657	573.	.493	1018.	.394	1590.	.328	2290.	.281	3117.	.246	4071.	.219	5153.	.197	6362.
5.6	.48695	.24347	1.05	264.	.702	594.	.527	1056.	.421	1649.	.351	2375.	.301	3233.	.263	4222.	.234	5344.	.210	6597.
5.8	.52235	.26117	1.12	273.	.749	615.	.562	1093.	.449	1708.	.374	2460.	.321	3348.	.281	4373.	.249	5535.	.224	6833.
6.0	.559	.279	1.19	283.	.797	636.	.598	1131.	.478	1767.	.398	2545.	.340	3464.	.299	4524.	.265	5725.	.239	7069.
6.2	.59689	.29844	1.27	292.	.846	657.	.635	1169.	.508	1826.	.423	2630.	.362	3579.	.317	4675.	.282	5916.	.254	7304.
6.4	.63602	.31801	1.34	302.	.897	679.	.673	1206.	.538	1885.	.448	2714.	.384	3695.	.336	4825.	.299	6107.	.269	7540.
6.6	.67639	.33819	1.42	311.	.949	700.	.712	1244.	.570	1944.	.474	2799.	.407	3810.	.356	4976.	.316	6298.	.285	7775.
6.8	.71801	.35900	1.50	320.	1.00	721.	.753	1282.	.602	2003.	.501	2884.	.430	3925.	.376	5127.	.334	6489.	.301	8011.
7.0	.76086	.38043	1.58	330.	1.05	742.	.794	1319.	.635	2062.	.529	2969.	.453	4041.	.397	5278.	.352	6680.	.317	8247.
7.2	.80496	.40248	1.67	339.	1.11	763.	.836	1357.	.669	2121.	.557	3054.	.477	4156.	.418	5429.	.371	6871.	.334	8482.
7.4	.85031	.42515	1.76	349.	1.17	785.	.880	1395.	.704	2179.	.586	3138.	.502	4272.	.440	5579.	.391	7061.	.352	8718.
7.6	.89689	.44844	1.85	358.	1.23	806.	.924	1433.	.739	2238.	.616	3223.	.528	4387.	.462	5830.	.410	7252.	.369	8954
7.8	.94472	.47236	1.94	368.	1.29	827.	.970	1470.	.776	2297.	.646	3308.	.554	4503.	.485	5881.	.431	7443.	.388	9189.
8.0	.99378	.49689	2.03	377.	1.35	848.	1.01	1508.	.813	2356.	.677	3393.	.580	4618.	.508	6032.	.451	7634.	.406	9425.
8.2	1.04409	.52204	2.12	386.	1.41	869.	1.06	1546.	.851	2415.	.709	3478.	.607	4734.	.532	6182.	.472	7825.	.425	9660
8.4	1.09565	.54782	2.22	396.	1.48	891.	1.11	1583.	.890	2474.	.741	3563.	.635	4849.	.556	6333.	.494	8016.	.445	9896
8.6	1.14844	.57422	2.32	405.	1.54	912.	1.16	1621.	.930	2533.	.774	3647.	.664	4964.	.581	6484.	.516	8206.	.465	10132.
8.8	1.20248	.60124	2.42	415.	1.61	933.	1.21	1659.	.970	2592.	.808	3732.	.693	5080.	.606	6635.	.539	8397.	.485	10367.
9.0	1.25776	.62888	2.53	424.	1.68	954.	1.26	1696.	1.01	2651.	.843	3817.	.722	5195.	.632	6786.	.562	8588.	.506	10603.
9.2	1.31428	.65714	2.63	434.	1.75	975.	1.31	1734.	1.05	2710.	.878	3902.	.752	5311.	.658	6936.	.585	8779.	.527	10839.
9.4	1.37204	.68602	2.74	443.	1.82	997.	1.37	1772.	1.09	2769.	.913	3987.	.783	5426.	.685	7087.	.609	8970.	.548	11074.
9.6	1.43105	.71552	2.85	452.	1.90	1018.	1.42	1809.	1.14	2827.	.950	4072.	.814	5542.	.713	7238.	.633	9161.	.570	11310.
9.8	1.49130	.74565	2.96	462.	1.97	1039.	1.48	1847.	1.18	2886.	.987	4156.	.846	5657.	.741	7389.	.658	9352.	.592	11545.
10.	1.55279	.77639	3.07	471.	2.05	1060.	1.53	1885.	1.23	2945.	1.02	4241.	.879	5773.	.769	7540.	.683	9542.	.615	11781.
10.2	1.61552	.80776	3.19	481.	2.12	1081.	1.59	1923.	1.27	3004.	1.06	4326.	.912	5888.	.799	7690.	.709	9733.	.638	12017.
10.4	1.6795	.83975	3.31	490.	2.20	1103.	1.65	1960.	1.32	3063.	1.10	4411.	.945	6004.	.827	7841.	.735	9924.	.662	12252.
10.6	1.74472	.87236	3.43	500.	2.28	1124.	1.71	1998.	1.37	3122.	1.14	4496.	.980	6119.	.857	7992.	.762	10115.	.686	12488.
10.8	1.81118	.90559	3.55	509.	2.36	1145.	1.77	2036.	1.42	3181.	1.18	4580.	1.01	6234.	.888	8143.	.789	10306.	.710	12723.
11.0	1.87888	.93944	3.67	518.	2.45	1166.	1.83	2073.	1.47	3240.	1.22	4665.	1.05	6350.	.919	8294.	.816	10497.	.735	12959.
11.2	1.94782	.97391	3.80	528.	2.53	1187.	1.90	2111.	1.52	3299.	1.26	4750	1.08	6465.	.950	8444.	.844	10687.	.760	13195.
11.4	2.01801	1.009	3.93	537.	2.62	1209.	1.96	2149.	1.57	3358.	1.31	4835.	1.12	6580.	.982	8595.	.873	10878.	.786	13430.
11.6	2.08944	1.04472	4.05	547.	2.70	1230.	2.02	2187.	1.62	3416.	1.35	4920.	1.15	6696.	1.01	8746.	.901	11069.	.811	13666.
11.8	2.16211	1.08105	4.19	556.	2.79	1251.	2.09	2224.	1.67	3475.	1.39	5005.	1.19	6812.	1.04	8897.	.931	11260.	.838	13902.
12.0	2.23602	1.11801	4.32	565.	2.88	1272.	2.16	2262.	1.73	3534.	1.44	5089.	1.23	6927.	1.08	9048.	.961	11451.	.865	14137.

S. MORGAN SMITH COMPANY

Loss in head in each 100 feet length of pipe at different velocities

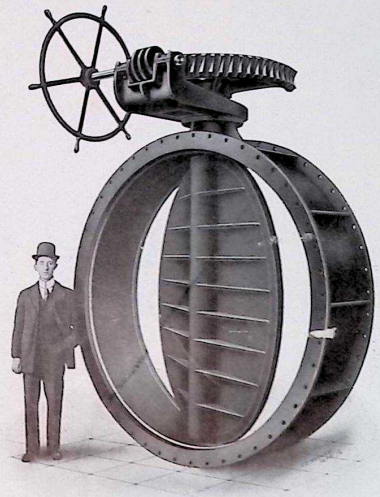
Vel. in Feet Per Second	Head Required to Produce Vel.	Head Required to Overcome Loss at Ent. of Pipe	FRICTION HEAD IN FEET FOR PIPES 100 FT. LONG FROM 5.50 TO 12.00 FT. DIA. INCLUSIVE WITH CUBIC FEET DISCHARGE PER MINUTE UNDER VELOCITIES FROM 1.00 TO 12.00 FT. INCLUSIVE PER SECOND															
			5.50 Dia.		6.00 Dia.		6.50 Dia.		7.00 Dia.		8.00 Dia.		9.00 Dia.		10.00 Dia.		11.00 Dia.		12.00 Dia.	
			Friction Head	Cubic Feet	Friction Head	Cubic Feet	Friction Head	Cubic Feet	Friction Head	Cubic Feet	Friction Head	Cubic Feet	Friction Head	Cubic Feet	Friction Head	Cubic Feet	Friction Head	Cubic Feet	Friction Head	Cubic Feet
1.0	.01552	.00776	..	1425.	..	1696.	..	1991.	..	2309.	..	3016.	..	3817.	..	4712.	..	5702.	..	6786.
1.2	.02236	.01118	.012	1711.	.011	2036.	..	2389.	..	2771.	..	3619.	..	4580.	..	5655.	..	6842.	..	8143.
1.4	.03043	.01521	.015	1996.	.014	2375.	.013	2787.	.012	3233.	..	4222.	..	5344.	..	6597.	..	7983.	..	9500.
1.6	.03975	.01987	.020	2281.	.018	2714.	.016	3186.	.015	3695.	.013	4825.	.012	6107.	.011	7540.	..	9123.	..	10858.
1.8	.05031	.02515	.024	2566.	.022	3054.	.020	3584.	.019	4156.	.017	5429.	.015	6871.	.013	8482.	.012	10264.	.011	12215.
2.0	.06211	.03105	.029	2851.	.027	3393.	.025	3982.	.023	4618.	.020	6032.	.018	7634.	.016	9425.	.014	11404.	.013	13572.
2.2	.07515	.03757	.035	3136.	.032	3732.	.029	4380.	.027	5080.	.024	6635.	.021	8397.	.019	10367.	.017	12544.	.016	14929.
2.4	.08944	.04472	.041	3421.	.037	4071.	.034	4778.	.032	5542.	.028	7238.	.025	9161.	.022	11310.	.020	13685.	.018	16286.
2.6	.10496	.05248	.047	3706.	.043	4411.	.040	5177.	.037	6004.	.032	7841.	.029	9924.	.026	12252.	.023	14825.	.021	17644.
2.8	.12173	.06086	.054	3991.	.049	4750.	.046	5575.	.042	6465.	.039	8445.	.033	10688.	.030	13195.	.027	15966.	.024	19001.
3.0	.13975	.06987	.061	4276.	.056	5089.	.052	5973.	.048	6927.	.042	9048.	.037	11451.	.033	14137.	.030	17106.	.028	20358.
3.2	.159	.0795	.069	4562.	.063	5429.	.058	6371.	.054	7389.	.047	9651.	.042	12214.	.038	15080.	.034	18246.	.031	21715.
3.4	.1795	.08975	.077	4847.	.070	5768.	.065	6769.	.060	7851.	.053	10254.	.047	12978.	.042	16022.	.038	19387.	.035	23072.
3.6	.20124	.10062	.085	5132.	.078	6107.	.072	7168.	.067	8313.	.058	10857.	.052	13741.	.047	16965.	.042	20527.	.039	24430.
3.8	.22422	.11211	.094	5417.	.086	6446.	.079	7566.	.074	8775.	.065	11460.	.057	14505.	.052	17907.	.047	21668.	.043	25787.
4.0	.24844	.12422	.103	5702.	.094	6786.	.087	7964.	.081	9236.	.071	12064.	.063	15268.	.057	18850.	.051	22808.	.047	27144.
4.2	.27391	.13695	.113	5987.	.103	7125.	.095	8362.	.088	9698.	.077	12667.	.069	16031.	.062	19792.	.056	23948.	.051	28501.
4.4	.30062	.15031	.123	6272.	.112	7464.	.104	8760.	.097	10160.	.084	13270.	.075	16795.	.067	20735.	.061	25089.	.056	29858.
4.6	.32888	.16444	.133	6557.	.122	7804.	.113	9159.	.105	10622.	.092	13873.	.081	17558.	.073	21677.	.066	26229.	.061	31216.
4.8	.35776	.17888	.144	6842.	.132	8143.	.122	9557.	.113	11084.	.099	14476.	.088	18322.	.079	22620.	.072	27370.	.066	32573.
5.0	.38819	.19409	.155	7127.	.142	8482.	.131	9955.	.122	11546.	.107	15080.	.095	19085.	.085	23562.	.077	28510.	.071	33930.
5.2	.41987	.20993	.167	7412.	.153	8821.	.141	10353.	.131	12007.	.115	15683.	.102	19849.	.092	24504.	.083	29650.	.076	35287.
5.4	.45279	.22639	.179	7698.	.164	9161.	.151	10751.	.140	12469.	.123	16286.	.109	20612.	.098	25447.	.089	30791.	.082	36644.
5.6	.48695	.24347	.191	7983.	.175	9500.	.161	11149.	.150	12931.	.131	16889.	.117	21375.	.105	26389.	.095	31931.	.087	38002.
5.8	.52235	.26117	.204	8268.	.187	9839.	.172	11548.	.160	13393.	.140	17492.	.124	22139.	.112	27332.	.102	33071.	.093	39359.
6.0	.559	.2795	.217	8553.	.199	10179.	.183	11946.	.170	13855.	.149	18095.	.132	22902.	.119	28274.	.108	34212.	.099	40716.
6.2	.59689	.29844	.230	8838.	.211	10518.	.195	12344.	.181	14316.	.158	18699.	.141	23666.	.127	29217.	.115	35352.	.105	42073.
6.4	.63602	.31801	.244	9123.	.224	10857.	.207	12742.	.192	14778.	.168	19302.	.149	24429.	.134	30159.	.122	36493.	.112	43430.
6.6	.67639	.33819	.259	9408.	.237	11197.	.219	13140.	.203	15240.	.178	19905.	.158	25192.	.142	31102.	.129	37633.	.118	44788.
6.8	.71801	.3590	.273	9693.	.250	11536.	.231	13539.	.215	15702.	.188	20508.	.167	25956.	.150	32044.	.136	38774.	.125	46145.
7.0	.76086	.3843	.288	9978.	.264	11875.	.244	13937.	.226	16164.	.198	21111.	.176	26719.	.158	32987.	.144	39914.	.132	47502.
7.2	.80496	.40248	.304	10263.	.278	12214.	.257	14335.	.238	16626.	.209	21714.	.185	27483.	.167	33929.	.152	41054.	.139	48859.
7.4	.85031	.42515	.319	10549.	.293	12554.	.270	14733.	.251	17087.	.220	22318.	.195	28246.	.176	34872.	.159	42195.	.146	50216.
7.6	.89689	.44844	.336	10834.	.307	12893.	.284	15131.	.264	17549.	.231	22921.	.205	29009.	.184	35814.	.168	43335.	.154	51574.
7.8	.94472	.47236	.352	11119.	.323	13232.	.298	15530.	.277	18011.	.242	23524.	.215	29773.	.194	36757.	.176	44475.	.161	52931.
8.0	.99378	.49689	.369	11404.	.338	13572.	.312	15928.	.290	18473.	.254	24127.	.225	30536.	.203	37699.	.184	45616.	.169	54288.
8.2	1.04409	.52204	.386	11689.	.354	13911.	.327	16326.	.303	18935.	.266	24730.	.236	31300.	.212	38642.	.193	46756.	.177	55645.
8.4	1.09565	.54782	.404	11974.	.370	14250.	.342	16724.	.317	19396.	.278	25334.	.247	32063.	.222	39584.	.202	47897.	.185	57002.
8.6	1.14844	.57422	.422	12259.	.387	14589.	.357	17122.	.332	19858.	.290	25937.	.258	32826.	.232	40527.	.211	49037.	.193	58360.
8.8	1.20248	.60124	.441	12544.	.404	14929.	.373	17521.	.346	20320.	.303	26540.	.269	33590.	.242	41469.	.220	50177.	.202	59717.
9.0	1.25776	.62888	.459	12829.	.421	15268.	.389	17919.	.361	20782.	.316	27143.	.281	34353.	.253	42412.	.229	51318.	.210	61074.
9.2	1.31428	.65714	.479	13114.	.439	15607.	.405	18317.	.376	21244.	.329	27746.	.292	35117.	.263	43354.	.239	52458.	.219	62431.
9.4	1.37204	.68602	.498	13400.	.456	15947.	.421	18715.	.391	21706.	.342	28349.	.304	35880.	.274	44297.	.249	53599.	.228	63788.
9.6	1.43105	.71552	.518	13685.	.475	16286.	.438	19113.	.407	22167.	.356	28953.	.316	36643.	.285	45239.	.259	54739.	.237	65146.
9.8	1.49130	.74565	.538	13970.	.493	16625.	.455	19512.	.423	22629.	.370	29556.	.329	37407.	.296	46182.	.269	55879.	.247	66503.
10.0	1.55279	.77639	.559	14255.	.512	16964.	.473	19910.	.439	23091.	.384	30159.	.341	38170.	.307	47124.	.279	57020.	.256	67860.
10.2	1.61552	.80776	.580	14540.	.532	17304.	.491	20308.	.456	23553.	.399	30762.	.354	38934.	.319	48066.	.290	58160.	.266	69217.
10.4	1.6795	.83975	.601	14825.	.551	17643.	.509	20706.	.472	24015.	.413	31365.	.367	39697.	.331	49009.	.300	59301.	.275	70574.
10.6	1.74472	.87236	.623	15110.	.571	17982.	.527	21104.	.490	24476.	.428	31969.	.381	40460.	.343	49951.	.311	60441.	.285	71932.
10.8	1.81118	.90559	.645	15395.	.592	18322.	.546	21503.	.507	24938.	.444	32572.	.394	41224.	.355	50894.	.322	61581.	.296	73289.
11.0	1.87888	.93944	.668	15680.	.612	18661.	.565	21901.	.525	25400.	.459	33175.	.408	41987.	.367	51836.	.334	62722.	.306	74646.
11.2	1.94782	.97391	.691	15965.	.633	19000.	.584	22299.	.543	25862.	.475	33778.	.422	42751.	.380	52779.	.345	63862.	.316	76003.
11.4	2.01801	1.009	.714	16250.	.655	19339.	.604	22697.	.561	26324.	.491	34381.	.436	43514.	.393	53721.	.357	65003.	.327	77360.
11.6	2.08944	1.04472	.737	16536.	.676	19679.	.624	23095.	.579	26786.	.507	34984.	.450	44277.	.405	54664.	.369	66143.	.338	78718.
11.8	2.16211	1.08105	.762	16821.	.698	20018.	.644	23494.	.598	27247.	.524	35588.	.465	45041.	.419	55606.	.381	67283.	.349	80075.
12.0	2.23602	1.11801	.786	17106.	.720	20357.	.665	23892.	.617	27709.	.540	36191.	.480	45804.	.432	56549.	.393	68424.	.360	81432.

Horse power transmitted by hammered steel shafting at different speeds as prime movers

Diam. Shaft	REV. PER MIN.																
	100	125	150	175	200	225	250	275	300	325	350	375	400	425	450	475	500
1 1/16	8.5	10.	13.	15.	17.	19.	21.	23	25.	28.	30	32.	34.	36.	38.	40.	43.
2 1/16	12.5	15.	18.	21	24.	27.	31.	34.	37.	40.	43.	46.	49.	52.	55.	58.	61.
2 1/16	17.	21.	25	30.	34.	38.	42.	47.	51.	55.	59.	64.	68.	72.	76	81.	85.
2 1/16	30.	37.	45.	52.	59.	67.	74.	82.	89.	97	104.	112.	119	126	134.	141	149.
3 1/16	48.	60.	71.	83.	95.	107.	119.	131.	143.	155.	167.	179.	191.	203.	215.	227.	239.
3 1/16	72.	90.	107.	125.	143.	161.	179.	197.	215.	233.	251.	269.	287.	305.	323.	341.	359.
4 1/16	102.5	128.	154.	179.	205.	231.	257.	282.	308.	334.	359.	385.	411.	436.	462.	488.	513.
4 1/16	141.5	177.	212.	248.	283.	319.	354.	389	425.	460.	496.	531.	566.	602.	637.	673.	708
5 1/16	189.	236.	284.	331.	378.	426.	473.	520.	567.	615.	662.	709.	756.	804	851.	898.	946.
5 1/16	246.	308.	369.	431.	493.	554.	616.	677.	739	800.	862.	924.	985.	1047.	1108.	1170.	1231.
6 1/16	314.	392.	471.	549.	627.	706.	784.	863.	941.	1020.	1098.	1176.	1255.	1333.	1412.	1490.	1569.
6 1/16	393.	491.	589.	687.	786.	884.	982.	1080.	1178.	1277.	1375.	1473.	1571.	1669.	1768.	1866.	1964.
7 1/16	484.	605.	726.	847.	968.	1089.	1210.	1331.	1452.	1573.	1694.	1815.	1936.	2057	2178.	2299.	2420.
7 1/16	588.	735.	883.	1030.	1177.	1324.	1471.	1618.	1765.	1912.	2059.	2206.	2353.	2500.	2647.	2794.	2942.
8 1/16	707.	883.	1060.	1237.	1413.	1590.	1767.	1943.	2120.	2297.	2473.	2650.	2827.	3003.	3180.	3357.	3534.
8 1/16	840.	1050.	1260.	1470.	1680.	1890.	2100.	2310.	2520.	2730.	2940.	3150.	3360.	3570.	3780.	3990.	4200.
9 1/16	989.	1236.	1483.	1731.	1978.	2225.	2472.	2719.	2967.	3214.	3461.	3708.	3956.	4203.	4450.	4697.	4945.
9 1/16	1155.	1443.	1732.	2020.	2309.	2598.	2886.	3175.	3464.	3752.	4041.	4329.	4618	4907.	5195	5484.	5773.
10 1/16	1338.	1672.	2007.	2341.	2675.	3010.	3344.	3679.	4013.	4348.	4682.	5016.	5351.	5685.	6020.	6354.	6689.
10 1/16	1539	1924.	2309.	2694.	3079.	3463.	3848.	4233.	4618.	5003.	5388.	5772.	6157.	6542.	6927.	7312.	7697.
11 1/16	1760.	2200.	2640.	3080.	3520.	3960.	4401.	4841.	5281.	5721.	6161.	6601.	7041.	7481.	7921.	8361.	8801.
11 1/16	2001.	2502.	3002.	3502.	4003.	4503.	5003.	5504.	6004.	6504.	7005.	7505.	8005.	8506.	9006.	9506.	10007

Horse power transmitted by nickel steel shafting at different speeds as prime movers

Diam. Shaft	REV. PER MIN.																
	100	125	150	175	200	225	250	275	300	325	350	375	400	425	450	475	500
1 1/16	11.5	14.5	17.	20.	23.	26.	28.	31.	34.	37.	40.	43.	46.	49.	51.	54.	57.
2 1/16	16.5	20.5	25.	29.	33.	37.	41.	45.	50.	54.	58.	62.	66.	70.	74.	79.	83.
2 1/16	23.	28.5	34.5	40.	46.	51.	57.	63.	69.	74.	80.	86.	92.	97.	103.	109.	115.
2 1/16	40.	50.	60.5	70.	80.	90.	100.	110.	120.	130.	140.	150.	161.	171.	181.	191.	201.
3 1/16	64.5	80.5	96.5	113.	129.	145.	161.	177.	193.	209.	226.	242.	258.	274.	290.	306.	322.
3 1/16	97.	121.	145.5	169.	194.	218.	242.	266.	291.	315.	339.	363.	388.	412.	436.	460.	484.
4 1/16	139.	173.	208.	243.	277.	312.	346.	381.	416.	450.	485.	520.	554.	589.	624.	658.	693.
4 1/16	191.	239.	287.	334.	382.	430.	478.	526.	573.	621.	669.	717.	764.	812.	860.	908.	955.
5 1/16	255.	319.	383.	447.	510.	574.	638.	702.	766.	829.	893.	957.	1021.	1085.	1148.	1212.	1276.
5 1/16	332.	415.	498.	581.	664.	747.	830.	913.	997.	1080.	1163.	1246.	1329.	1412.	1495.	1578.	1661.
6 1/16	423.	529.	635.	741.	847.	953.	1058.	1164.	1270.	1376.	1482.	1588.	1694.	1799.	1905.	2011.	2117.
6 1/16	530.	662.	795.	927.	1060.	1192.	1325.	1457.	1590.	1722.	1855.	1987.	2120.	2252.	2385.	2517.	2650.
7 1/16	653.	816.	979.	1143.	1306.	1469.	1632.	1796.	1959.	2122.	2285.	2449.	2612.	2775.	2938.	3102.	3265.
7 1/16	794.	992.	1191.	1389.	1588.	1786.	1984.	2183.	2381.	2580.	2778.	2977.	3175.	3374.	3572.	3770.	3969.
8 1/16	953.	1192.	1430.	1668.	1907.	2145.	2383.	2622.	2860.	3098.	3337.	3575.	3814.	4052.	4290.	4529.	4767.
8 1/16	1133.	1416.	1699.	1983.	2266.	2549.	2832.	3116.	3399.	3682.	3965.	4249.	4532.	4815.	5098.	5382.	5665.
9 1/16	1334.	1667.	2001.	2334.	2668.	3001.	3335.	3668.	4002.	4335.	4669.	5002.	5336.	5669.	6003.	6336.	6670.
9 1/16	1558.	1947.	2337.	2726.	3116.	3505.	3895.	4284.	4674.	5063.	5453.	5842.	6232.	6621.	7011.	7400.	7790.
10 1/16	1805.	2256.	2707.	3159.	3610.	4061.	4512.	4964.	5415.	5866.	6317.	6769.	7220.	7671.	8122.	8574.	9025.
10 1/16	2077.	2596.	3115.	3635.	4154.	4673.	5192.	5712.	6231.	6750.	7269.	7789.	8308.	8827.	9346.	9866.	10385.
11 1/16	2375.	2969.	3562.	4156.	4750.	5344.	5937.	6531.	7125.	7719.	8312.	8906.	9500.	10094.	10687.	11281.	11875.
11 1/16	2700.	3375.	4050.	4725.	5400.	6075.	6750.	7425.	8100.	8775.	9450.	10125.	10800.	11475.	12150.	12825.	13500.



Engraving No. 303

Flutter Gate

We build flutter gates of this design to meet requirements. They can be built with bell ends when desired. They are so built that the leakage is comparatively small.